Documentation Summaries

ASTRA TECH Implant System™
ATLANTIS™
Facilitate™

DENTSPLY IMPLANTS

Publisher

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Welcome

Are you looking for information about the outstanding results on maintained marginal bone levels when using ASTRA TECH Implant System™? Or do you want to explore the biomechanical principles and theories behind our implant system design? You will find the answers here, and much more.

Documentation Summaries provides a thorough synopsis of the published key research supporting ASTRA TECH Implant System, ATLANTIS™ and Facilitate™. Each summary is based on facts retrieved from the original article.

Documentation Summaries issue 8 is divided into the following sections:

For a more comprehensive view of the documentation and research on our products, please refer to our Scientific Reviews. The Scientific Reviews are available for download at www.dentsplyimplants.com.

A continuous evolution

1985 Taking the first step towards the ASTRA TECH Implant System BioManagement Complex™.

1991 MicroThread™ The idea of minute threads on the implant neck to ensure positive biomechanical bone stimulation and maintained marginal bone level is born. After comparing 840 threads of different shapes and sizes, the optimal profile for positive stress distribution is identified.

1992 All intellectual properties on the OsseoSpeed™ surface are acquired and the development process starts together with the University of Oslo.

1990 OsseoSpeed™ A team at the University of Oslo, Norway, starts asking themselves, "what if you could speed up the osseo-integration process by chemically modifying the implant surface?" The idea of a fluoride modified implant surface is born.

1991 The first clinical study with MicroThread™ on a tapered implant neck is initiated.

1989 The idea of blasting the implant surface with titanium dioxide particles to increase bone growth and osseo-integration is presented and the TiOblast™ surface is born.

1993 A straight implant with MicroThread™ is developed and launched.

2002 The first clinical multicenter study on OsseoSpeed™ is initiated.

1993 The first experimental pre-clinical studies on OsseoSpeed™ are initiated.

1990 The first clinical study on the TiOblast™ surface is initiated, followed by the TiOblast implant launch.

1985 Clinical use of the first generation of implants with Conical Seal Design™ and Connective Contour™ is initiated in a study at the Karolinska University Hospital in Stockholm, Sweden.

2009 ASTRA TECH Implant System™, one of the most thoroughly documented dental implant systems in the world, is proven clinically to maintain the marginal bone level.

2000 The first patient receives an OsseoSpeed™ implant at the University of Oslo.

2001 A randomized controlled clinical trial on a fluoride modified surface of orthopedic implant is started.

2010 OsseoSpeed™ TX is launched. TX stands for tapered apex and it is introduced on the complete implant assortment.

2011 OsseoSpeed™ TX Profile, the unique, patented implant that is anatomically designed for sloped ridges, is introduced.

2004 The first and only chemically modified implant surface – OsseoSpeed™ – is launched at EAO in Paris. Based on the remarkable results, the expression "more bone more rapidly" is coined.

2003 The FOCUS project, a unique effectiveness study, is initiated, involving more than 100 clinicians in Europe and the United States.

2006 New results on the OsseoSpeed™ surface and its biological responses demonstrate the importance of the fluoride modified surface with its unique nanoscale topography.

ASTRA TECH
IMPLANT SYSTEM

BioManagement Complex™

A successful implant system cannot be determined by one single feature alone.
Just as in nature, there must be several interdependent features working together.
The following combination of key features is unique to ASTRA TECH Implant System™:

- **OsseoSpeed™** — more bone more rapidly
- **MicroThread™** — biomechanical bone stimulation
- **Conical Seal Design™** — a strong and stable fit
- **Connective Contour™** — increased soft tissue contact zone and volume

ASTRA TECH Implant System BioManagement Complex™

This section is designated to articles that describe and explain the mechanisms behind the four key features of the ASTRA TECH Implant System BioManagement Complex™, i.e. OsseoSpeed™, MicroThread™, Conical Seal Design™ and Connective Contour™.

The following summaries are from both pre-clinical and clinical scientific articles, and for example, you will find the 5-year clinical performance of the OsseoSpeed implant.

Effects of fluoride-modified titanium surfaces on osteoblast proliferation and gene expression

Isa ZM, Schneider GB, Zaharias R, Seabold D, Stanford CM
Int J Oral Maxillofac Implants 2006;21(2):203-11

Purpose: Implant surface topographies have been shown to influence the differentiation and proliferation of osteoblasts, and the up regulation of transcription factors that are responsible for the expression of bone matrix formation genes. The purpose of the current study was to evaluate if a fluoride-modified implant surface affects the bone matrix formation genes. Secondly the aim was also to evaluate if a well defined rough surface topography on the nanometer level can affect cell shape and gene expression.

Materials and Methods: Titanium discs were treated with either titanium grit blasting with 25 µm particles (TB, TiOblast™) or titanium grit blasting with 25 µm particles followed by treatment with dilute hydrofluoric acid (TBF, OsseoSpeed™). An additional group of discs blasted with 125µm particles were also prepared (ER, extra rough).

All surfaces were studied for characterization and comparison of the topography under scanning electron microscopy (SEM).

Discs were seeded with micromass cultures of human palatal mesenchymal cells (HEPM) with 50,000 cells/10µL and left to grow for 72 hours, at which time scanning electron microscopy (SEM) was used to study cell morphology on the TB and TBF surfaces. Tissue culture plastic (TCP) was used as a control. Cell proliferation was evaluated at 1 day, 3 days and 1 week.

Alkaline phosphatase (AKP) activity was analyzed using a commercial kit and a KC4 microplate data acquisition software, to measure the phosphate concentration per culture (pmol/750 µL). In addition, the expression of alkaline phosphatase (ALP), core binding factor 1 (cbfa1), Osterix (Ox), type I collagen (tIcol), bone sialoprotein (BSP) and osteocalcin (Oc) were analyzed using real time PCR strategies performed in 96-well Optical Reaction Plates in an ABI Prism 7700 Sequence Detection System. Statistical analysis was performed using one-way ANOVA with Tukey's Multiple Comparison test.

Results: The SEM revealed that all surfaces had an isotropic topography with the TB being the smoothest and the TBF and ER having similar topographies. At high magnification the TBF demonstrated secondary nano-pores which where not found on the other surfaces.

After 72 hours there was evidence of cell spreading with flattened cells on all surfaces. Hence, different surface morphologies or the fluoride modification seemed not to influence cell shape.

AKP activity was significantly lower for TCP compared to all titanium discs ($p<0.001$) at days 3 and 7. However, there was no significant difference between the cells on the 3 titanium groups in AKP activity at 3 and 7 days. This indicate a similar and high expression of the osteoblastic phenotype from the cells on these surfaces, at the longer time periods.

With respect to cell proliferation, all discs demonstrated a progressive increase in cell numbers, but by day 3 TCP, the smooth control surface, demonstrated a significantly higher number of cells when compared to all 3 rough surfaces, $p < 0.001$. There were no significant differences between the 3 test surfaces. By the end of the week TB and TCP were comparable but TBF and ER demonstrated a net reduction in cell numbers by 20%, $p < 0.001$ compared to TB and TCP.

With respect to gene expression TBF demonstrated a significant increase in cbfa1 compared to the other titanium surfaces at 7 days, $p < 0.01$, doubling between days 3 and 7. Oc also increased from day 3 to 7 but for all surfaces, while the levels for the other markers were the same for all surfaces at all time points.

Discussion and Conclusions: In the current study smoother surfaces were shown to optimize cell proliferation, however the fluoride treatment of the titanium surface appeared to optimize the upregulation of cbfa-1, a transcription factor that is essential for the maturation and differentiation of mesenchymal stem cells into osteoblasts. Other factors such as cell spreading and AKP activity were comparable between the different titanium surfaces. This suggests the TBF surface may be better disposed to support and promote cellular differentiation and potential to enhance osteogenesis.

Bone healing at implants with a fluoride-modified surface: an experimental study in dogs

Berglundh T, Abrahamsson I, Albouy JP, Lindhe J
Clin Oral Implants Res 2007;18(2):147-52

Purpose: In the early loading or immediate loading protocol for dental implants it is recognized that a process occurs during the initial healing phase which transfers the retention of the implant from a mechanical to a biological phenomenon over a period of approximately 4 weeks. During this osseointegration phase a coagulum is seen to re-organize with granulation tissue which is subsequently replaced by a matrix that leads to new bone formation. The need to enhance or optimize conditions for osseointegration of the implant during this critical phase is important and has been shown to be improved by surface microtexturing. In addition some studies have indicated that there may be some additional benefits derived from biochemical modifications, in particular the addition of fluoride ions on to the surface of the implant. This study set out to evaluate the effects of fluoride on the early stages of osseointegration by histological examination.

Materials and Methods: Six mongrel dogs had all their mandibular premolars and first mandibular molars extracted. Three months later one side of the mandible was exposed and 6 implants were placed. Two geometrically identical implants were used, and both were equipped with MicroThread™ on the implant neck. The control implants had a TiOblast™ surface (TiOblast™, ASTRA TECH Implant System™), (TB) and the test implants had a fluoride modified surface (OsseoSpeed™, ASTRA TECH Implant System) (OS). The surface roughness (Sa) was moderate in both cases and were for TB 1–1.2 µm and for OS 1.4-1.5 µm. Four weeks after the first implants were randomly placed the procedure was repeated on the contralateral side of the mandible. After a further 2 weeks of healing the animals were sacrificed, and each implant was removed *en bloc* and prepared for histological analysis of either fractured decalcified 3 µm sections stained with toluidine blue or 20 µm ground sections also stained with toluidine blue. The degree of bone-to-implant contact (% BIC) was assessed within the micro- and macro-threaded portion of all the implants. The tissue filling the void between the cut bone wall and the macro-threads of the implant immediately following implant installation was also evaluated to study early bone formation. Differences between the implant types were analyzed using student's t-test, at the 95% confidence level.

Results: Healing was uneventful and no implants were lost. After 2 and 6 weeks the % BIC at the MicroThread portion of both the TB and OS implants were similar. In the macro-threaded portion at 2 weeks the % BIC was 57% for the OS implants and 43% for the TB implants, ($p < 0.05$). At 6 weeks respective values were 61% and 59%. The % BIC in the wound chamber showed a significant difference at 2 weeks with 72% for OS implants compared to 60% for the TB implants, ($p < 0.05$). At 6 weeks respective values were 61% and 67%.

With respect to the tissue composition, after 2 weeks the wound chamber had 25–30% mineralized bone, which mainly consisted of woven bone (approx 20%). The amount of mineralized bone increased to approximately 50% at 6 weeks with a significant decrease in the constituent proportion of woven bone which had been replaced by lamellar bone. Tissue composition and proportion was similar at both TB and OS implants.

Discussion and Conclusion: Previous studies have demonstrated the influence of surface roughness to enhance the rate of early bone formation and osseointegration. Typically these studies have compared roughened implants to machined implants where differences in the Sa values are considerable. In the current study a microtextured implant was used as the control and as such had a similar Sa value to that of the test implant which was modified only by the incorporation of fluoride ions. The finding that there was significantly more new bone formed within the wound chamber and along the macro-threaded portion of the OS implant surface at 2 weeks is noteworthy since it suggests that the fluoride modified surface enhances and promotes osseointegration in the early phase of healing following implant installation and that in this particular test it was not dependent on surface roughness. These findings are in agreement with previously published data from Ellingsen et al (JOMI, 2004) and Cooper et al (Biomaterials, 2006) which would imply that osteoblast differentiation and new bone formation is enhanced by the addition of fluoride.

The effect of hydrofluoric acid treatment of TiO_2 grit blasted titanium implants on adherent osteoblast gene expression *in vitro* and *in vivo*

Guo J, Padilla RJ, Ambrose W, De Kok IJ, Cooper LF
Biomaterials 2007;28(36):5418-25

Aim: It is generally accepted that different surface treatments of the titanium implant can improve the osseointegration especially when evaluating for example the bone-to-implant contact. This study aimed to investigate how different surfaces (TiOblast™ and OsseoSpeed™) affected the bone cells specific gene expressions *in vitro* and *in vivo.*

Material and methods: Implant surface preparations of TiOblast and OsseoSpeed were done by the manufacturer (DENTSPLY Implants*). Coin shaped pure titanium discs (Ø 8 mm) for *in vitro* tests and screw shaped 1,5x1.0 mm with a 0,2 mm screw pitch implants for *in vivo* tests were produced. A machined titanium surface served as control. All implants were cleaned and sterilized according to standard procedures. The implant topography of TiOblast and OsseoSpeed were characterized by scanning electron microscopy (SEM) and chemical surface composition by photo electron spectroscopy (XPS).

Cultured human mesenchymal osteoblastic stem cells (MC3T3-E1) were allowed to attach to the discs with the different surfaces. Initiation of osteoblastic differentiation (evaluated by measurement of ALP) was started after 18 h of plating and was allowed for 1, 3, 7 and 14 days. At the end of each time point, adherent cells were lysed and analyzed for total RNA (UV spectroscopy) and mRNA (via cDNA and polymerase chain reaction). Genes encoding for RUNX-2, Osterix and BSP, which are closely related to the process of osteogenesis, were evaluated.

Sprague-Dawley rats received 3 implants in both tibiae, distal to the diaphyse, by a stepwise drilling protocol. The rats were sacrificed using a CO_2 chamber method after 1, 3 and 7 days. Each tibiae was harvested where after the implants were retrieved and subjected for gene expression analysis. A standardized control for gene functionality was performed (GAPHD) while doing the *in vitro* and *ex vivo* gene expression analysis.

Results: SEM analysis showed a nano-scale (100 nm) surface feature on the OsseoSpeed implant only. XPS analysis did not reveal any differences between the compounds of carbon, nitrogen, oxygen and titanium on the TiOblast and OsseoSpeed surfaces, however, 0.8 atomic % of fluoride was detected on the OsseoSpeed surface.

In vitro osteogenic expression (RUNX-2, Osterix and BSP) from cells on machined titanium, OsseoSpeed and TiOblast discs were low at day 1, significantly increased and peaked at day 3, somewhat lower at day 7 and turned again low at day 14 (fig. 1). The osteogenic expression from cells on the machined titanium discs was in general lower compared to the expression from cells adhered on OsseoSpeed and TiOblast discs. Cells adherent to OsseoSpeed discs expressed the highest mean values of RUNX-2 and Osterix at all time periods. The marker BSP showed higher levels from OsseoSpeed adherent cells compared to TiOblast adherent cells at day 1, thereafter no difference in expression between the adherent cells on OsseoSpeed respectively TiOblast were found.

In vivo implant surface adherent cells expressed in general increased activity at day 7 compared to earlier time points (fig 1). Adherent cells from the OsseoSpeed implants expressed higher levels of the osteogenic markers RUNX-2, ALP and BSP at 1, 3 and especially after 7 days (8-9 fold) of implantation compared to TiOblast adherent cells. Osterix expression was never detected from any cells *in vivo* neither from OsseoSpeed nor from TiOblast associated cells.

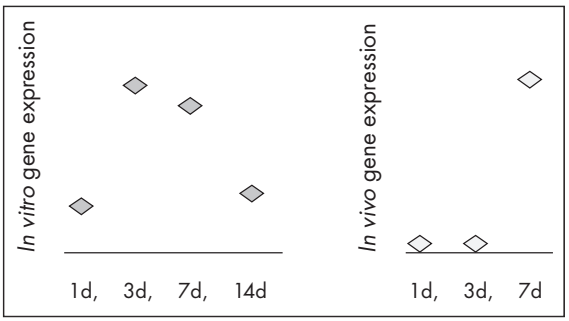


Figure 1. *General pattern of osteogenic expression from cells adherent to discs* ***in vitro*** *and screw shaped implants* ***in vivo.*** *This pattern is representative irrespective of implant surface and marker. Y-axis relative level (no scale), x-axis show time periods.*

Discussion and Conclusions: It was concluded by SEM and XPS analysis that only the OsseoSpeed surface had nano-scaled features and a fluoride content. *In vitro* and *in vivo* results were consistent and showed that the surface properties of the OsseoSpeed surface support the osteogenic adherent cell response compared to the TiOblast adherent cells. Further investigations of the mechanisms that control interfacial bone formation is undertaken.

**DENTSPLY Implants is the union of Astra Tech Dental and DENTSPLY Friadent*

Early loading of surface modified implants in the posterior mandible – 5 year results of an open prospective non-controlled study

Schliephake H, Rodiger M, Phillips K, McGlumphy EA, Chacon GE, Larsen P
J Clin Periodontol 2012;39(2):188-95

Aim: The long-term proof of principles of the titanium grit blasted and hydrofluoric treated titanium implants so called OsseoSpeed™, was desired at study initiation. The main objective of this trial was to evaluate the long-term clinical and radiographic outcome when applying an early loading protocol using OsseoSpeed implants placed in the posterior mandible.

Material and methods: After the ethical approval (at each of the 3 study centers) inclusion to this open non-controlled study started in May 2004. General criteria for implant treatment and specific conditions such as no need for grafting, no immediate placement in extraction sockets, being a non-smoker, the need of at least 2 implants (in molar position and splinted) and an initial stability enough to be early loaded, had to be fulfilled in order for the patient to be included. OsseoSpeed implants of varying lengths and dimensions were placed and UniAbutments™ were connected in a 1-stage surgical approach. Sutures were removed after 2 weeks and impression was taken after 6 weeks after healing. Screw-retained metal ceramic bridges were delivered within 7 weeks of implant placement. Clinical variables were evaluated throughout the whole study period and consisted of bleeding on probing (BOP), plaque index (PI) and the recording of technical and biological complications. Radiographic measurement of the marginal bone level (MBL) was performed at implant placement, loading, 3 and 6 months post loading and at yearly visits. Analysis was performed using standardized procedures (incl. calibration) by an independent radiologist. Implant stability by means of resonance frequency analysis (ISQ values) was performed regularly during the first year (implant placement being the start value).

For PI and BOP, descriptive statistics was calculated on implant level, thereafter on patient level and finally averaged on visit level. For ISQ and MBL descriptive statistics were calculated on implant level then averaged on visit level. When longitudinal changes were analyzed, a repeated-measures-ANOVA and a pair wise comparisons t-test, at a level of $p < 0.05$, were applied.

Results: At time of loading the patient group consisted of 44 patients with 50 restorations supported by 123 OsseoSpeed implants. These 22 male and 22 female patients had a mean age of 57 years. Bilateral rehabilitation occurred in 11 patients and the use of 3 implants were more common than a 2 implant solution. Two patients diseased and 1 patient was lost to follow-up during the 5 year follow-up period. At the final visit a 100% bridge survival and 100% implant survival were reported. Biological complications consisted of 3 patients having peri-implantitis (discovered at 2 and 4 yrs), which was treated successfully by open surgery, debridement and rinsing. One patient had numbness in the lip, which resolved spontaneously and another patient received a postoperative infection that was cured by antibiotics. Four events of abutment loosening, 5 events of bridge screw loosening/fracture and 9 events of ceramic chipping occurred. The loosenings were dealt with by occlusal adjustment and framework fit and veneer chipping were polished (bridges had to be sent to lab for repair in 2 instances).

PI at patient level was 28.6% at loading, 13.3% 3 months later and 17.4% at the end of the study. BOP at patient level varied throughout the functional loading period between 7-13%. ISQ values decreased significantly from 73.3 at implant placement to 71.9 at 2 weeks. They were, however, 73.2 at 6 weeks and continued to increase during the first year of function, and ended at 77.7 at five years of follow-up. Mean marginal bone level change (MBLC) from implant placement to loading was -0.21 mm. From loading and onwards some gain occurred resulting in a total change from implant placement to 5 years of -0.08 mm. Sixty-one of the implants showed no change in bone levels during the observational period.

Discussion and Conclusions: This study shows that the OsseoSpeed implant is a safe and predictable implant when treating posterior edentulism applying an early loading protocol. Soft tissue health and marginal bone can be preserved at a constant level throughout 5 years of function.

The implant neck: smooth or provided with retention elements. A biomechanical approach

Hansson S
Clin Oral Implants Res 1999;10(5):394-405

Purpose: This study set out to establish the influence on peak bone stress at the bone-to-implant interface by providing retention elements along the entire length of the implant neck, and to also evaluate the impact of bi-cortical fixation and implant axial stiffness, which have also been shown to help in reducing peak bone stresses.

Materials and Methods: Calculations were made using finite element analysis. In order to obtain sufficient accuracy, initial data was calculated from a 3-dimensional (3-d) model of a 72 mm long uniform section of a mandible, built up with 8 node cubic elements, in order to evaluate its elastic behaviour. Data from this model was then transferred into a simpler axisymmetric model built up with 4 node square elements. This axisymmetric model was then adjusted to ensure that relative displacement of upper and lower cortices under a 200 N centrally located load was similar to that obtained in the 3-d model. Certain assumptions were incorporated into the modelling of the bone to allow for its viscoelastic behaviour and to avoid the formation of high peak stress artifacts which were seen to occur at singular points. It was also assumed that for a smooth implant surface only compressive stresses would be resisted, compared to compressive and shear stresses for a surface provided with retention elements.

Into this axisymmetric model a 3.5 mm diameter titanium implant was inserted, built up with 4 node elements and with appropriate information on the modulus of elasticity and Poisson's ratio for titanium. The width of the central bore was altered so that the wall thickness varied between 0.3–0.8 mm which in turn would affect axial stiffness of the implant and its surface was either modelled to be smooth or rough by the incorporation of retention elements, all the way to the top of the implant. Additionally, variations in thickness of the cortical bone were modelled and the implant length was varied to allow for uni- and bi-cortical fixation.

A 1000 N vertical load was applied evenly to all upper implant nodes and the influence of surface character, wall thickness and the presence of uni- or bi-cortical fixation was calculated with regards to the peak interfacial bone stress.

Results: When considering the influence of surface characteristic for implants with bi-cortical fixation, and a wall thickness of 0.6 mm, peak interfacial shear stress reduced from 80.6 MPa to 29.6 MPa when the neck was characterized with retention elements. Indeed in all calculations there was always an approximate 60 to 80% decrease in peak stress when the implant neck was characterized with retention elements. An increase of wall thickness from 0.3 to 0.8 mm decreased peak stresses by only 10 to 20%. The influence of uni- or bi-cortical fixation was similar.

Discussion and conclusion: The majority of implants have a smooth cervical portion around which significant bone loss has been reported, particularly for those with a long conical shaped neck. However Palmer et al., have reported remarkable maintenance of marginal bone around similarly shaped implants provided with retention elements. It has been postulated that with a smooth neck the bone does not partake in distributing axial load and suffers from atrophy according to Wolff's law. By contrast the interlock afforded by retention elements allows for the axial load to be dissipated via interfacial shear which has been shown to be a critical stressor.

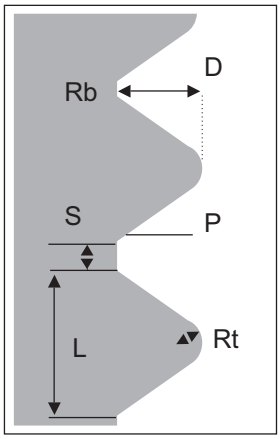
It can be concluded that the provision of retention elements (micro-architecture and/or micro-thread), an increase in axial stiffness of the implant and bi-cortical fixation will all enhance the performance of an implant to resist higher axial loads.

The implant thread as a retention element in cortical bone: the effect of thread size and thread profile: a finite element study

Hansson S, Werke M
J Biomech 2003;36(9):1247-58

Purpose: The purpose of this study was to evaluate the effect of different thread profiles and dimensions on the interfacial bone stress of an idealized axially loaded implant using finite element analysis (FEA).

Materials and Methods: The Ansys (V5.0) program was employed for the FEA utilizing the theory of elasticity. A 3.5 mm screw shaped implant of infinite length (c.f. ASTRA TECH Implant System™) was model in cortical bone with the threads modelled as a bead whose profile and dimension could be varied. Thread profile parameters were depth (D), top radius of curvature (Rt), bottom radius of curvature (Rb) flank angle (P), and the straight section between the threads (S). The length of the base of the thread was designated (L).



A 100% bone-to-implant contact was assumed permitting frictionless sliding and only compressive stresses transferred between implant and bone. The bone was modelled to be isotropic and homogenous with a Poisson's ratio of 0.3. Test analyses were performed to confirm that a higher than normal modulus could be applied without affecting the calculated stresses. This was necessary to avoid the abruptness of stiffness to complete rigidity, which had to be bridged by the contact elements between the implant and bone. An axial load of 5 N/mm x implant length was applied and the data captured was the peak tensile stress and the peak compressive stress in the bone as a function of the values of the differing thread profiles. The element mesh was made up of 1129 elements, each comprising four nodes. Each node had two degrees of freedom.

Results: In all the calculations for the different thread profiles the peak tensile stress was located outside the top of the thread. The peak compressive stress was located on the lower slope of the top radius of curvature except for large flank angles combined with long value for S, when the peak compressive stress was located close to the bottom of the thread flank.

Using convergence analysis it was determined that a thread depth of 0.1 mm was as effective as a thread depth of 0.4 mm. As such very small threads could in fact prove remarkably effective at distributing functional stresses. In addition a low ratio between the top radius of the curvature, Rt and thread depth, D should be avoided since deep sharp threads gave rise to deleterious stress concentrations.

With regard to the distance between threads it appears that the influence of this parameter is dependant on other factors, as such for a continuous thread profile where the distance S is extremely small, the Rt and P influence the stresses. In such a case a value for Rt equal to 0.4–1.0 times the thread depth and a value for P equal to 40–60 degrees yields low values for tensile stress. When the threads are separated and the distance S is large the flank angle should be approximating 0 degrees, since for large flank angles high tensile stresses are recorded where the threads are separated by an increasing distance S.

Finally with respect to Rb it was assumed that a value 0.1 times the thread depth was optimal since the stresses were not located in this area.

Discussion: In the current study the model of a stiff, infinitely long, axially loaded implant embedded in homogenous, isotropic, cortical bone, with a frictionless interface and 100% bone-to-implant contact is far from clinical reality. However, the model was established to allow the distribution of stress in the bone to be identical outside all threads thereby allowing a comparison between threads of different size and profile. In addition the attempt to understand the pure effect of thread profile and dimension on bone stresses warrants this idealistic approach. Its findings then require clinical validation.

The FEA results indicated that the thread profile did influence the stress peaks in bone. In addition it appeared that subject to a favourable profile, very small microthreads were equally as effective as large threads. In addition it could be stated that a small value for the top radius of the curvature, Rt, is to be avoided and a large value for the section between the threads, S is unfavourable for most thread profiles as is a large value for the bottom radius of the curvature, Rb.

Effects of implant design and surface on bone regeneration and implant stability: an experimental study in the dog mandible

Rasmusson L, Kahnberg KE, Tan A
Clin Impl Dent Rel Res 2001;3(1):2-8

Purpose: The current study set out to investigate whether an alteration to implant surface texture by means of grit-blasting and/or the addition of retention elements as a MicroThread™ would influence the healing of marginal bone defects and the associated implant stability.

Materials and Methods: Three implant types were employed in the study, these were Brånemark System 3.75 x 8.5 mm (BS) which were machine prepared, and ASTRA TECH Implant System™ ST 4.5 x 9 mm (ATM) respectively MicroThread™ 4.0 x 9 mm (ATM), which both present with a titanium grit-blasted surface and so-called MicroThread™ in the coronal third of the implant. The ATST implants also present with a tapered coronal collar.

One of each implant was immediately inserted into the socket of either P2 or P3 premolars, which were extracted bilaterally in each one of six greyhound dogs, under anaesthesia. Crestobuccal bone defects measuring 3 x 3 mm were created adjacent to the implants on one side only (test side), with the contralateral alveolus being left intact to act as control. A transducer was attached to all implants in order to measure their baseline resonance frequency (ISQ value) to assess their interfacial stiffness, before flaps were repositioned and implants benefited from submerged healing for 4 months.

After the healing period a second ISQ value was recorded. Thereafter all animals were sacrificed and implant specimens were removed *en bloc* and fixed in formalin. Specimens were embedded, sectioned and ground to 10 µm prior to staining with toluidine blue 1% and Pyronin-G. Histomorphometric evaluation was carried out on both sides of each specimen to measure the percentage bone-to-implant contact (BIC), the percentage bone area in all threads (BA), and the distance from each implant's reference point to the most coronal bone contact.

Results: Healing was uneventful and all implants showed some degree of bone regeneration at the defect sites. When considering the ISQ values there was a typical increase in stiffness for all implants as a result of osseointegration in both test and control groups, which tended to be more significant for ATST and ATM. In addition the change in ISQ at 4 months compared to baseline for test implants compared to control implants reached statistical significance for both ASTRA TECH Implant System types ($p < 0.05$).

Histomorphometry revealed a statistically significant increase in mean BIC for ASTRA TECH Implant System types compared to the Brånemark implant with 4-month values measuring 51% (ATM) > 47.4% (ATST) > 23.6% (BS) for test and control implants combined. Mean BA measured 38.9% (ATST) > 36.7% (ATM) > 32.5% (BS) for test implants and 42.1% > 41.3% > 34.8% for control implants respectively.

The mean distance from each implant's reference point to the most coronal bone contact was significantly longer for the Brånemark implants compared to the ASTRA TECH Implant System types ($p < 0.05$) measuring 2.70 mm (BS) 2.20 mm (ATM) > 2.18 mm (ATST).

Discussion: The finding in this study that implants with a roughened surface result in an increased BIC is supported in the literature from human, animal and *in vitro* studies. It is also interesting to note that the distance to the most coronal bone at defect sites was notably shorter for these same roughened implants. This may also be related to the MicroThread. Increase in ISQ values was mostly attributable to osseointegration, however some notable relative increase in ISQ was seen for roughened implants. Whether new bone filling in the defects provides any additional stability can not be verified. Data would suggest this to be unlikely, either due to lack of integration or possibly due to its immature structure.

Effect of microthread on the maintenance of marginal bone level: a 3-year prospective study

Lee DW, Choi YS, Park KH, Kim CS, Moon IS
Clin Oral Implants Res 2007;18(4):465-70

Purpose: Maintenance of the peri-implant marginal bone is not only seen as essential for functional support of the implant but today it is identified as the key to the maintenance of a healthy and esthetic peri-implant mucosa, which is central to treatment success. Previous studies have identified that bone initially undergoes resorption settling typical 1.5 mm below the implant shoulder at the first thread. It has been proposed that such bone loss can be prevented by the provision of retention elements at the top of the implant in the form a rough microtextured surface (RMS) and/or the provision of MicroThread™ (MT). Within the ASTRA TECH Implant System™, implants have been presented with both RMS and a combination of RMS with MT. This might explain the variable data on marginal bone levels, but to date no direct comparison has been made. As such this study was established to compare two RMS implants, one with and one without MT, to determine the impact on the long-term marginal bone levels.

Materials and Methods: Seventeen patients requiring implant therapy for replacement of at least two missing adjacent teeth were enrolled in the study. Subjects had to complete a periodontal program and demonstrate good oral hygiene maintenance. Implants were selected to be RMS (4.0 mm Ø, TiOblast™) or RMS/MT (4.5 mm Ø, ST) and both types were placed in a randomized order in all patients. A two-stage surgical protocol was utilized and prostheses were delivered 3 months after exposure.

Patients were reviewed every 3 months and an assessment was made of pain, implant stability, gingival inflammation and superstructure complications annually along with evaluation of intra-oral radiographs taken in a Rinn device and with a standardized technique. Images were digitized and a measure was made on the mesial and distal aspects from a fixed reference point at the base of the coronal bevel to the first point of bone contact. Any bone above the reference point was given a value of zero. Results were subject to statistical analysis using Wilcoxon's signed-rank test at the $p < 0.01$ level.

Results: A total of 34 implants were inserted, of which 22 were in the maxilla and 12 were in the mandible. All implants osseointegrated and all prostheses were successfully delivered without complications or symptoms up to the 3-year recall. The mean marginal bone loss measured 0.14 mm, 0.21 mm and 0.24 mm for RMS/MT implants at the 1- , 2- and 3-year recalls respectively. These values were consistently lower than for RMS-only implants where bone loss measured 0.28 mm, 0.48 mm and 0.51 mm respectively. Differences were highly statistically significant at all time frames, ($P = 0.001 – 0.002$). In addition there was a notable trend to indicate the rate of bone loss was lower for those implants which benefited from a MicroThread™, particularly from baseline to the end of the first year, ($P = 0.002$). The amount of bone loss was significantly higher for both implants when comparing the first year to those subsequent.

Discussion and Conclusion: Many factors have been identified as possible contributors to marginal bone loss. These include the presence of a machined surface without retention elements, the establishment of a biologic width, the disruption of the soft tissue interface by utilizing healing abutments, implant geometry the presence or absence of periodontal disease. In the current study both implants presented with an identical RMS to the top of the implant and both utilized an internal 11° conical interface which should in theory dictate identical biologic width requirements. In addition the use of healing abutments and a two-stage approach was identical for both implant types ruling out these factors as confounding variables. While it is recognized that the implants varied in diameter by some 0.5 mm, this has been shown in a previous study not to have influenced bone loss. As such it is believed that this study allowed a true interpretation of the influence of the MicroThread on the implant, although it is accepted that patients will have had different periodontal susceptibilities.

Although, early biomechanical resistance to initial loading within the first year could not be verified, this study clearly showed that implants that benefited from MicroThread demonstrated a significantly lower marginal bone loss over a 3-year period compared to implants without MicroThread.

Implant-abutment interface: biomechanical study of flat top versus conical

Hansson S

Clin Impl Dent Rel Res 2000;2(1):33-41

Purpose: The aim of this study was to determine the impact of having a conical versus a flat-top fixture-abutment connection on the induced stress patterns within the bone surrounding an implant with a microthreaded portion, via finite element analysis.

Material and Methods: The finite element method is a very powerful mathematical tool used to calculate the stresses in a structure.

An axisymmetric finite element model of the mandible was used, with previously established parameters for elastic constants. The bone and titanium were assumed to be isotropic, having the same elastic properties in all directions. The implant was modeled to represent a 3.5 mm diameter implant with either an 11-degree internal connection or a flat-to-flat connection. Axial stiffness decreased at the apical end to simulate the macrothreads of an implant reducing the overall wall thickness compared to the microthreaded region.

Axial loads of 1000 N were applied to both systems, with either an even load distribution over the surface or concentrated on selective nodes.

Principal stresses in the bone and the interfacial shear stress were calculated on the assumption that there was no fusion between implant and bone, such that the interface could not resist tensile stress. Interlocking between implant and bone was modeled by connecting interfacial implant and bone nodes in a vertical direction resisting shear.

Results: Peak interfacial shear stresses measured between 44 and 100 MPa for the flat-to-flat connection becoming progressively worse when the load applied was modeled only on a lateral node contact.

For the conical connection the stresses ranged from 26 to 32 MPa, when applying the same load. In addition the stress distribution patterns were markedly different with load being concentrated at the most coronal margin for the flat-to-flat connection but being more evenly distributed and at a deeper level, on the implant surface in the bone, for the conical connection.

A similar pattern was noted for the principle stresses which ranged from –32.4 to –277.7 MPa and from –8.5 to –103.3 MPa for the two connections respectively. These stresses were compressive in nature.

Discussion: While the principal stresses recorded were higher than the interfacial shear stress recorded for both connections, the forces were compressive in nature, which is well tolerated by cortical bone. In this respect the shear stress is considered to be of greater significance.

Furthermore while clinical function of implant supported prostheses will lead to a variety of vectorial loads and moments, it is likely that only the axial loads will result in interfacial shear stresses, and these can be most destructive if the shear strength of the interface is exceeded, leading to slip and fracture of the interfacial tissues.

In the current finite element analysis it was apparent that the induced stresses were reduced by the application of the axial load along the internal conical surface of the implant. This also resulted in a more even and deeper distribution of the stress taking it away from the more delicate marginal region. This would indicate that an implant with a conical interface can theoretically resist a bigger axial load before triggering bone resorption. In gene-ral terms the results also indicate that a favorable stress distribution can be accomplished by a more central and deeper application of the axial load.

An *in vitro* evaluation of the strength of an internal conical interface compared to a butt joint interface in implant design

Norton MR

Clin Oral Implants Res 1997;8(4):290-8

Purpose: The aim of the study was to compare the strength of the fixture/abutment and abutment/bridge cylinder interfaces for implants utilizing a butt joint and a conical joint design.

Materials and Methods: The ASTRA TECH Implant System™ and Brånemark implant were used to represent the conical joint and butt joint designs respectively, with units being assembled according to manufacturer's recommendations.

Each implant was screwed into a metal beam at one end, with the abutment or bridge-cylinder being clamped to another beam at the opposite end. In order to assess the strength of the implant/abutment and abutment/bridge cylinder interfaces, the 3-point bending test was utilized, with the application of a known force at right angles to the interface, by means of a screw driven loading device. For each system and each interface, 6 units were tested.

Recordings were made for both the point of first plastic bending, recorded as a 0.3 mm deformation and also maximum bending to failure. The displacements were recorded on a Linear Variable Differential Transformer (LVDT). Load and displacement were analysed using an appropriate software program.

Results: For the implant/abutment interface, the mean moments required to register the point of first plastic deformation was 1315 Nmm and 645 Nmm for the conical joint and butt joint respectively, with a mean moment force of 2030 Nmm and 1262 Nmm to cause failure of each joint. The difference between the moments was highly statistically significant ($p = 0.00010$ and $p < 0.0010$, respectively). Furthermore the coefficient of variance was low confirming the strict homogeneity of both material and design, in both systems, which would suggest that the results would be reproducible in larger sample.

In the ASTRA TECH Implant System failure did not result in either elongation or abutment fracture, however it is likely that imperceptible vertical hair-line fractures did occur at the neck of the implant. For the Brånemark system there was a notable elongation of the abutment screw with loosening of the joint.

When testing the two systems at the abutment/bridge cylinder interface, the mean moments required to register the first point of plastic deformation were 994 Nmm and 725 Nmm for the conical and butt joints respectively, with a moment force of 1866 Nmm and 1305 Nmm required to cause failure of each joint, which for the ASTRA TECH Implant System was a fracture of the bridge screw, but for the Brånemark system, the abutment screw was once again seen to be the focus of deformation. Again the differences were statistically significant ($p < 0.010$ and $p = 0.0001$, respectively).

Discussion: Biomechanical failure has become the focus of concern with a constant source of data drawing attention to the problems of screw loosening and screw fracture.

Whilst numerous efforts have been made to address this problem, in particular with the introduction of the torque driver, there has been little data published confirming the efficacy of the butt joint or other designs to resist bending moments.

This study has demonstrated that the conical joint is significantly superior to the butt joint in resisting bending moments when tested in the extreme, such as in the 3-point bending apparatus described, and that furthermore the abutment screw is the weakest point in the butt joint design and not the bridge screw, when using the Estheticone system.

Micro-movements at the implant-abutment interface: measurements, causes and consequenses

Zipprich H, Weigl P, Lauer H-C, Lange B
Implantologie 2007;15:31-45

Purpose: Most of two-component or multi-component implant systems use an implant-abutment connection with a clearance fit. The clinical impact is assumed as high according to the following factors: 1) Implant systems consisting of two or several components are much more widespread than single component systems because they offer a number of well-known clinical and technical advantages. 2) Unconnected crowns in the posterior region are more susceptible to technical failure of the implant-abutment interface. 3) Crestally or subcrestally placed implant-abutment interfaces are frequently subjected to crestal bone resorption following abutment connection. This *in-vitro* study examined the dynamic behaviour of different designs of implant-abutment connections

Materials and methods: Abutments were loaded at an angle of 30° with a force of up to 200 N. The distance of the point of force application from the implant platform was 8 mm; the gradation of the force was 0.3 N/ms. The interface of the implant-abutment connection was examined and measured radiographically using a professional high speed digital camera (1,000 images per second).

Result: The results showed that, under simulated clinical conditions, complex mechanisms are responsible for the presence or absence of a micro-motion. All implant-abutment connections with a clearance fit exhibit a micro-motion (implant systems: SIC®; Replace Select®; Camlog®; XIVE®; Straumann synOkta®; Bego-Semados®; Straumann massive conical abutment®). Precision conical connections (implant systems: Ankylos®; ASTRA TECH Implant System™) show no micromotion.

Implant	Index	Micro-spalt at 200 N
ASTRA TECH Implant System™	dodecagonal	0.0 µm
Ankylos®	non indexed	0.0 µm
Straumann massive abutment®	non indexed	0,1–4 µm
Bego-Semados®	hexagonal	0,1–4 µm
Replace Select®	3-positions	12–16 µm
XIVE®	hexagonal	16–20 µm
Straumann synOkta®	oktagonal	20–24 µm
SIC®	hexagonal	28–32 µm
Camlog®	3-positions	32–36 µm

Discussion: The potential clinical relevance of these results can at this point only be derived from theoretical considerations. Presumably, the pumping effect caused by the micro-motion plays an important role for crestal bone resorption. It is assumed that the bone is contaminated with liquid contained in the implant.

For videotape clips and English abstract see www.kgu.de/zzmk/werkstoffkunde

Molecular leakage at implant-abutment connection-in vitro investigation of tightness of internal conical implant-abutment connections against endotoxin penetration

Harder S, Dimaczek B, Acil Y, Terheyden H, Freitag-Wolf S, Kern M
Clin Oral Investig 2009;14(4):427-32

Peri-implant soft tissue reactions and marginal bone loss are thought to be induced by amongst other things implant-abutment joint instability and microleakage of bacteria and bacterial endotoxins. Such microleakage has previously been demonstrated in two-piece implants where micro-gaps exist at the joint. The advent of tightly fitting internal conical joints has promise since these joints have been shown to eradicate micro-movement and thus it is proposed perhaps microleakage.

Purpose: Since endotoxins represent much smaller molecular components than whole bacteria, this study set out to test the presence or absence of endotoxin microleakage in two systems previously shown to benefit from tight internal conical implant-abutment joints.

Materials and Methods: The systems under test were the ASTRA TECH Implant System™ (AT) using a two-piece hollow abutment with abutment screw (TiDesign™) and the ANKYLOS® (AK) system using a one-piece solid abutment (b/3.0/4.0).

All components were heat treated and handled in ultra-sterile conditions in a microbiological cabinet with laminar air flow to avoid external contamination. Eight implants of each system were inoculated with 0.5 µl of lipopolysaccharide endotoxins extracted from Salmonella Enterica at a concentration of 20 mg/ml. The endotoxin was pipetted into the deepest internal aspect of each implant prior to abutment connection and tightening to manufacturer's recommended torque. Assembled units were then agitated in a bath of supernatant at a frequency of 20 motions/min. Samples of supernatant were collected at intervals of 5 minutes, 24, 72, and 168 hours. Implants with endotoxin inoculation for 0 minutes served as control.

The collected sample was then subject to the QCL-1000 chromogenic limulus amebocyte lysate test which allows detection of endotoxin from gram negative bacteria. This is achieved by the use of a spectrophotometer to evaluate any change in optical density of the supernatant which turns yellow (when the chromogenic substance react with endotoxin) at a wavelength of 405–410 nm.

Results for each system and each time point were subject to statistical analysis using one-sided Wilcoxon signed rank tests and the Friedman test, with significance set at the 95% confidence level.

Results: In the AK group endotoxin contamination was observed for all samples within 5 minutes of agitation, without exception. In the AT group 3 implants showed no sign of contamination after 5 min and after 72 h still 2 implants showed no signs of contamination. One implant remained contamination free even after 168 h of agitation. There was a direct correlation between agitation time and degree of contamination for both systems. ($p < 0.01$). Significantly less contamination was observed for AT implants at every time point when compared to AK implants, $p < 0.05$.

Discussion and Conclusion: It is conceded that the heat treatment used in the current study to ensure absence of any unrelated confounding contamination of the implant components might have affected the tightness and hence the resistance to microleakage of the internal joints under test. Nonetheless all samples, except one (AT) demonstrated microleakage within the given time frame up to 168 h post contamination.

To avoid external contamination all efforts were made to ensure components and equipment used as well as the experimental set-up were free from extrinsic contamination. If contamination was noted at time 0min (baseline) it was assumed contamination had occurred in error and the sample was excluded from analysis.

Results from the current study concur with previous studies but show the AT implants to yield statistically less microleakage at all sampling points. This may be due to the smaller gap size reported at the conical implant-abutment junction for AT implants (1–2 µm) compared to that for AK implants (4 µm) (Jansen et al 1997).

The barrier between the keratinized mucosa and the dental implant. An experimental study in the dog

Moon IS, Berglundh T, Abrahamsson I, Linder E, Lindhe J
J Clin Periodontol 1999;26(10):658-63

Purpose: The connective tissue and junctional epithelium constitute the effective barrier between the oral environment and the peri-implant bone. The purpose of the present study was to investigate the tissue composition that forms the transmucosal passage around, and attachment to a dental implant.

Materials and Methods: 36 implants (TiOblast™ ASTRA TECH Implant System™) were inserted in the healed ridge of 6 dog mandibles and left submerged to osseointegrate for 3 months. Abutments were then connected (UniAbutment™ 45°) and a plaque control program was initiated.

The dogs were euthanized after 6 months by intra-arterial perfusion of a fixative. En bloc specimens were processed for the "fracture technique", and subsequently embedded in EPON. 3 µm thin histological sections were stained with PAS and toluidine blue. In addition ultra thin (0.05 µm) uranyle acetate and lead citrate contrasted sections were also produced.

Light microscopic analysis was performed using a Leica DM-RBE® microscope equipped with an image-capture system (Q-500 MC®; Leica, Germany). The area analyzed was the closest peri-abutment tissue (length 200 µm x 20 µm wide) interposed between the apical border of the junctional epithelium and the bone, called zone A. Continuous with and lateral (or outer) to zone A, zone B was defined (length 200 µm x 160 µm wide).

Determination of the proportions (%) of collagen, fibroblasts, vascular structures and residual tissue (e.g.leucocytes, nerves, matrix components) were analyzed histometrically.

Electron micrographs were obtained from the ultra thin sections revealing the proportion of fibroblasts (using a point counting procedure and a 42-point lattice) in two zones, where one zone (30 µm wide, located within zone A) was innermost next to the implant-abutment surface, and the other zone (30 µm wide, located within zone B) was at a peripheral distance of 150 µm.

The null hypothesis was rejected at $p<0.05$, and the Student t-test for paired observations was applied.

Result: The most coronal barrier, the junctional epithelium, was 2 mm long and 40 µm wide. The connective tissue analyzed seemed to be in direct contact with the implant surface. Light microscopic evaluation indicated a structural difference between the innermost and lateral tissues. The innermost tissues (zone A) were characterized by an abundance of fibroblasts (28%) oriented parallel with the implant surface, and interposed by thin collagen fibers (66,47%) which originated from the periosteum of the bone crest running vertically. There was an absence of vascular structures in the inner zone.

The outer zone (B) housed more and larger collagen fibers (82,36%) running in various directions, and a substantial number of vessels (3,27%), but relatively few fibroblasts (10%) were identified. When comparing the inner and outer zones all variables evaluated were found to reach a statistically significant difference, $p < 005$.

Discussion and conclusion: The overall result from this study on the composition of the peri-implant connective tissue is in agreement with previously reported data in similar models. Furthermore it confirms that the periimplant tissues are structurally different from gingiva.

A previous hypothesis (from the same group of authors) has speculated that the scar-like barrier tissue composition and the paucity of cells could imply that the peri-implant tissue has a lower turn-over than gingiva. In the present study however, a more detailed histological analysis was performed and the previous hypothesis could not be confirmed. To the contrary, there are reasons to assume that the high number of fibroblasts plays a role in the establishment and maintenance of the mucosal barrier and that the tissue next to the implant have a high turn-over.

The mucosal barrier at implant abutments of different materials

Welander M, Abrahamsson I, Berglundh T
Clin Oral Implants Res 2008;19(7):635-41

Aim: The objective of this *in vivo* study was to analyze the soft tissue characteristics at abutments of different materials connected to pure titanium implants, OsseoSpeed™.

Material and methods: In total 6 dogs were included. Mandibular and maxillary premolars were extracted under general anesthesia and the alveolus were left to heal for 3 months. Using a 1-stage surgical protocol, (flap surgery), 4 OsseoSpeed™ 4.5 ST x9 mm implants were placed in one side of the mandible. Healing abutments were connected and the soft tissue were sutured carefully and the area left to heal for another month. By randomization, 4 new abutments of similar geometry and size, but of different materials, were connected. Two abutments were made of pure titanium, one was ceramic (ZrO_2) and one so called Cast-to i.e. made of AuPt-alloy. Hereafter, a plaque control program was started and undertaken for 5 months. On the contra-lateral jaw side implant placement and abutment installations were initiated 3 months after connection of the experimental abutments, making the total time of plaque control to be 2 months. The dogs were sacrificed by glutaraldehyde fixation via the carotid artery.

Specimens for light microscopic evaluation were prepared through careful and stepwise fixation, decalcification and staining. A modified fracture technique was applied resulting in 3 µm thick sections (toluidine blue and PAS stained). The preparation technique allowed for four different sections to be analyzed, mesio-buccal, disto-buccal, mesio-lingual and disto-lingual. At the light microscopic level, 4 parameters were determined: 1) the marginal portion of the peri-implant oral mucosa, 2) the apical border of the junctional epithelium, 3) the implant-abutment junction, 4) the level of the bone-implant contact. The abutment close connective tissue composition (in an 80 µm wide zone parallel to the surface) was analyzed by a stereological technique. Hereby relative numbers of different type of cells could be determined. By the same method, the number of leucocytes in the barrier epithelium was analyzed. Mean values were calculated on abutment level. To calculate differences between groups the Student's t-test was used.

Results: No complications occurred during surgery, however, one implant was lost during the osseointegration phase. The result from the light microscopic analysis showed that the epithelial and connective tissue structure at titanium and ceramic abutments were similar at 2 and 5 months follow-up. At the AuPt-alloy abutments an apical shift was observed in the level of the barrier epithelium and marginal bone between 2 and 5 months. This was not observed around ceramic and titanium abutments. The tissue composition at AuPt-alloy abutments was also different than that at titanium and ceramic abutments. AuPt-alloy close tissue displayed lower amount of collagen and fibroblasts and higher numbers of inflammatory cells than the titanium and ceramic close tissue. In fact the ceramic material displayed significantly lower numbers of leucocytes in the barrier epithelium at 2 months compared to the titanium close tissue.

Figure 1. Schematic drawing of implant and healing abutment with surrounding hard and soft tissue. ***1)*** *the marginal portion of the peri-implant oral mucosa,* ***2)*** *the apical border of the junctional epithelium,* ***3)*** *the implant-abutment junction,* ***4)*** *the level of the bone-implant contact.*

Discussion and Conclusions: This study shows that the soft tissue healing around titanium and ceramic abutments is stable between 2 and 5 months. The soft tissue at AuPt-alloy abutments was not as stable as around the titanium and ceramic abutments indicating a different healing pattern around the AuPt-alloy abutment material.

Peri-implant tissues at submerged and non-submerged titanium implants

Abrahamsson I, Berglundh T, Moon IS, Lindhe J
J Clin Periodontol 1999;26(9):600-7

Purpose: To study the hard and soft tissue integration around ASTRA TECH Implant System™ components when used in a conventional one-stage and two-stage transmucosal surgical technique.

Material and Methods: This animal study used the partially edentulated mandibles of 6 beagle dogs. Three months post-extraction, 3 TiOblast™ implants 8 x 3.5 mm were inserted unilaterally, with the most coronal bevel of the implants at the crestal cortical margin. Cover screws were placed and implants submerged for 3 months prior to a second surgical procedure to expose and secure UniAbutments of 1.5 mm and 3.0 mm in length. At the same time a further 3 implants were surgically inserted in the contra-lateral side, with the coronal bevel of the implants once again level with the crestal cortical bone. However for these implants, abutments were placed immediately and soft tissues sutured around them for transmucosal healing. All dogs were routinely followed-up with daily hygiene.

Radiographs were taken using a modified Eggen technique to allow the accurate measurement of mesial and distal bone levels at time of fixture placement, 3 months post insertion and 6 months post insertion. Measurements were made mesially and distally using an imaging system under light microscope.

Clinical examinations were carried out to record plaque scores and a modified gingival index. Animals were sacrificed 9 months after the first implantation procedure and implants were harvested *en bloc* prepared and embedded for ground sections or for the fracture technique to allow histometric analysis of the dimensions and type of hard and soft peri-implant tissues, with particular attention to the *zone of connective tissue integration*. In addition a digital assessment of bone-to-implant contact in both the coronal unthreaded and threaded portions of the implant were undertaken. Results were subject to statistical analysis.

Results: Clinically all implants included in the analysis demonstrated successful osseointegration and very low levels of plaque and excellent soft tissue health. Radiographs revealed that over the 9 months follow-up marginal bone loss measured as a mean 0.42 mm for implants subjected to the two-stage technique and 0.3 mm for those treated transmucosally. Histology revealed identical tissue types to be found in relation to the various implant components. Histometric measurements revealed a very close approximation for the two groups with the junctional epithelium measuring as a mean 1.9 mm, the connective tissue compartment measuring 1.17 mm and the distance from the abutment/fixture junction to the marginal bone level measuring 0.8 mm as a mean. With regards the morphometric measurements for the connective tissue zone again there was a very close approximation for all fractions including collagen, vessels, fibroblasts and residual tissues. Bone-to-implant contact for the coronal unthreaded portion measured 75.0% for the one-stage implants and 72.6% for the two-stage implants and 61.4% and 66.7% respectively for the threaded portions.

There was no statistical difference for any parameters measured.

Discussion: The notion that an implant can be left exposed at the time of surgical insertion, without impacting on the tissue integration has been questioned and studied with various implants. This study compared the two surgical techniques for the TiOblast™ fixture and UniAbutment. Results clearly indicated that the tissue types, their dimensions and morphometry were identical regardless of procedure and that the percentage of bone-to-implant contact and marginal bone height is also unaffected.

In similar experimental set up differences in radiographic bone loss compared to this result have been reported, in favour for the ASTRA TECH Implant System. Differences most likely explained by the different design characteristics of the implant systems evaluated (i.e. features related to the characteristics and design of the abutment connection).

Incidence of inter-proximal papilla between a tooth and an adjacent immediate implant placed into a fresh extraction socket: 1-year prospective study

Lops D, Chiapasco M, Rossi A, Bressan E, Romeo E
Clin Oral Implants Res 2008;19(11):1135-40

There have been numerous publications on the immediate placement of single-tooth implants into fresh extraction sockets with the purpose of preserving both the hard and soft tissue framework including the interproximal papillae in order to achieve a good esthetic result. The success of implants placed in this manner has been very high typically > 90% and often > 95%. While some studies have questioned the ability of an implant to prevent bone resorption following extraction, numerous studies have presented data demonstrating maintenance of the interproximal papilla so long as the vertical distance from the crest of bone to the contact point did not exceed 5 mm.

Purpose: The current study was set up to assess both the vertical and horizontal distances necessary to ensure maintenance of the interproximal papilla at single-tooth implants.

Materials and Methods: Forty-six systemically healthy patients who smoked less than 10 cigarettes per day, demonstrated no evidence of parafunction and were deemed to have a thick or normal biotype were enrolled to the study for replacement of a single tooth using an immediate extraction and insertion protocol, for the placement of an OsseoSpeed™ implant. Thirty-two maxillary and 14 mandibular teeth were atraumatically extracted using luxators and forceps under full flap reflection, after which sockets were thoroughly curetted to remove any residual periodontal remnants. Osteotomies were prepared according to manufacturer's recommendations and the coronal margin of the implants was leveled at the crest labial bone to achieve an appropriate emergence profile. Temporary healing abutments were secured and flaps repositioned and sutured to ensure complete coverage of the residual socket defect. Temporary restorations were fabricated and secured after 8 weeks and definitive ceramo-metal restorations placed 3 months later. 15 restorations were based on customized Cast-Design™ abutments, 21 on prepared Profile Bi-Abutments™ and 10 on zirconia Zir-Design™ abutments. All abutments were secured according to manufacturer's recommendations and either ceramo-metal or all-ceramic crowns cemented on top.

Clinical parameters assessed were gingival index, presence or absence of papilla, where less than or equal to half the papilla fill to the contact point rendered a papilla "absent". The distance from the coronal margin of the implant to the adjacent tooth (dI-T) and the distance of the peak of bone adjacent to the tooth to the contact point (dPBT-CP) were measured on digitalized (and calibrated to the known implant length) radiographs at the 12-months review. Repeat measurements were taken for 10 radiographs to determine intra-observer variability and results were subject to statistical analysis using the X^2-test.

Results: All implants osseointegrated. A total of 92 interproximal sites were evaluated and the intra-observer variability was negligible. In 97% of sites the gingival index was 0. The mean dI-T for mesial and distal sites was 3.2 mm and 3.1 mm respectively and the mean dPBT-CP measured 5.6 mm for both mesial and distal sites. Using odds ratio it could be demonstrated that when dI-T was 3–4 mm the papilla was present 84% of the time, $p < 0.05$. By contrast when dI-T was < 3 mm it was only present 32% of the time although this was not statistically significant. With respect to dPBT-CP, when the value measured was 3–5 mm the papilla was present 80% of the time, $p < 0.05$, however for measurements of 6–7 mm the papilla was present only 51% of the time (NS).

Discussion and Conclusions: It is apparent from the current results that the position of an implant in an apico-coronal as well as a mesio-distal direction is critical to the maintenance of a full interproximal papilla and the accomplishment of an esthetic result. In addition it has been previously reported that immediate implant placement might yield more favorable results in this regard when compared to a delayed approach. As with previous reports this study supports the proposal that the peak of the bone related to the adjacent tooth is more influential than that related to the implant, with the distance dPBT-CP being identified for control of papilla fill.

However this is also dependent on the location of the contact point which should be 5 mm from this bone peak. The OsseoSpeed implant was seen to perform extremely well in the immediate single-tooth replacement scenario.

Surgical techniques

A wide range of different surgical techniques are applied when placing implants, depending on preconditions. Today, standard implant surgery protocol can be a 1-stage surgical approach, as well as immediate placement in a fresh extraction socket. More advanced surgical techniques include bone augmentation and sinus lift procedures.

Standard surgical procedures

Advanced surgical techniques

Related reading:

Bone level alterations at implants placed in the posterior segments of the dentition: outcome of submerged/ non-submerged healing. A 5-year multicenter, randomized, controlled clinical trial.

Cecchinato D, Bengazi F, Blasi G, Botticelli D, Cardarelli I, Gualini F
Clin Oral Implants Res 2008;19(4):429-31

Purpose: This study set out to evaluate the long-term marginal bone level changes at implants placed using a one- or two-stage surgical protocol.

Materials and Methods: Eighty-four healthy patients were randomly assigned to either a one-stage (group A) or two-stage (group B) surgical protocol for the insertion of 324 implants (TiOblast™ 3.5, 4.0) to support Fixed Partial Dentures, FPDs. As an inclusion criteria, patients had to present with an adequate amount of bone to receive implants of at least 9 mm in length without recourse to grafting. In the current cohort 25% of the patients were smokers.

Implants were placed according to manufacturer's protocol. For implants in group A, standard UniAbutments were connected at the same operative procedure as implant placement and were left exposed to the oral cavity during the healing phase. For implants in group B, cover screws were placed and the implants were submerged for a healing period of 3 months in the mandible and 6 months in the maxilla. At this time all submerged implants were exposed in a conventional manner and UniAbutments were connected.

The restorative treatment followed recommended protocol for the fabrication of screw-retained FPDs. At definitive prosthesis connection, baseline records were taken for plaque score, mucositis, and intraoral radiographs were taken for bone level measurements. The same follow-up data was recorded at yearly visits during the 5 years course of the study.

Results were statistically analyzed.

Results: Four implants in group A and 3 in group B failed to integrate (early failures), 5 of these implants were recorded as having a reduced primary stability. Another 3 implants were lost during the first year (2 fractured and 1 was removed due to advanced bone loss). At the 5-year follow-up, 35 implants were lost to follow-up. Among these, 3 patients (11 implants) had died during the course of the study. In total, 10 bridge screws fractured (5 patients), and 8 veneers had to be replaced (5 patients).

Plaque and mucositis scores were low throughout the study.

Radiographic measurements revealed a mean marginal bone loss of only 0.02 mm for group A implants and 0.17 mm for group B implant after 1 year in function with no significant differences between the groups. After another 4 years in function there was some mean radiographic bone gain in group A (0.07 ± 0.5 mm), and a slight bone reduction in group B (0.02 ± 0.6 mm), but these were not statistically significant from each other. Only 16 implants (4 in group A and 12 in group B) experienced bone loss > 2 mm during the study period.

Discussion and Conclusion: The current study was conducted as a randomized controlled study to determine the influence of one- versus two-stage surgical protocol on the long-term marginal bone response. Clinical and radiographic outcome variables indicate that the use of a one-stage surgical protocol did not impact upon the implant success rate, peri-implant soft tissue health, or the change in marginal bone levels which were very minor. Neither did the treatment modality affect the number of technical complications.

Immediate and conventional single implant treatment in the anterior maxilla: 1-year results of a case series on hard and soft tissue response and aesthetics

Raes F, Cosyn J, Crommelinck E, Coessens P, De Bruyn H
J Clin Periodontol 2011;38(4):385-94

Purpose: The main purpose of this study was to investigate midfacial soft tissue responses following single immediate implant placement as well as conventional implant placement. Secondly, the aim was to evaluate if the aesthetic outcome was dependent on the different implant treatment protocols.

Materials and Methods: Thirty-nine patients treated for single failing teeth or single tooth edentulism in the anterior maxilla were consecutively included in the study and rehabilitated with 39 OsseoSpeed™ implants. Strict inclusion criteria were followed where the patients had to be at least 18 years, have at least 20 teeth present, sign an informed consent, have good oral hygiene, optimal soft tissue conditions and sufficient bone volume to receive an implant to be included in the study.

Patients with a failing tooth in place, was assigned to the immediate implant placement group, where the implant was placed in the extraction sockets applying flapless surgery (FS group). The gap to the buccal bone plate at the level of the implant shoulder was registered as <2mm or ≥2 mm. In case of an already lost tooth the patient was assigned to the conventional implant placement group, where a minimal mucoperiosteal flap method was applied (MH group). The implants were seated in a way that at least 2 mm distance was left between implant shoulder and neighboring teeth. The implant shoulder was placed palatal to the neighboring teeth and leveled with the buccal bone crest. No grafting was performed. A provisional acrylic crown was temporarily cemented onto a Direct Abutment™, hence all implants were subjected to immediate loading. Approximately 10 weeks after implant placement and provisionalization permanent ceramic crowns were cemented.

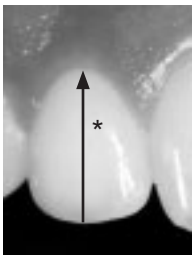
The patients were scheduled for follow-ups at 4, 12, 26 and 52 weeks whereupon implant survival soft tissue remodeling was evaluated and radiological examination was performed. Pink esthetic score (PES) and white esthetic score (WES) was evaluated only at the 52-week follow-up. Esthetic scores and soft tissue remodeling was analyzed from standardized digital color photographs.

For statistical analysis the patient was used as a unit with the level of significance set to 0.05. Friedman test was applied for analysis of changes over time. Mann-Whitney test was used to evaluate effect of surgical techniques, the size of the bone gap and the gingival biotype on the soft tissue changes.

Results: One implant failure occurred during the early healing phase in the FS group rendering a total implant survival rate of 93.8% after 1 year in function. Marginal bone level analysis failed to show significant changes over time in either group or between groups at the final appointment. Both treatment groups showed stable mesial and distal papillae over time. At the final visit, it was found that the flapless surgery applied in the FS group lead to significantly less recession of the midfacial soft tissue as to when a flap surgery was applied (MH group, p=0.023). Acceptable aesthetic outcomes were demonstrated in 68% of the overall cases when applying PES and WES. Eight % showed an almost perfect outcome and the remaining 24% had unacceptable esthetic outcomes noted.

	FS group	MH group
Mesial papilla	stable	stable
Distal papilla	slightly decreased	stable
Mid facial soft tissue*	recession 7% unchanged 80% gain 13%	recession 43% unchanged 57% gain 0%
White esthetic score	7.2 (SD=2.04)	7.0 (SD=2.37)

Table 1. One year results of soft tissue response, evaluated through standardized digital photographs.



Discussion and Conclusion: Immediate flapless surgery showed stable midfacial soft tissue in contrast to conventional surgery utilizing a small flap technique where recessions were obvious. The results from this study showed that irrespective of when implant placement occurs esthetic perfection for single implant crowns is very difficult to achieve, even in a well selected patient population as presented in this study.

Comparison of radiographic and clinical outcomes following immediate provisionalization of single-tooth dental implants placed in healed alveolar ridges and extraction sockets

Cooper LF, Raes F, Reside GJ, Garriga JS, Tarrida LG, Wiltfang J, Kern M, de Bruyn H
Int J Oral Maxillofac Implants 2010;25(6):1222-32

Purpose: The aim of this clinical investigation was to compare single-tooth implants placed in either healed sites or placed immediately after tooth extraction in the anterior maxilla, with respect to implant survival, hard tissue remodeling, papillae changes and buccal mucosal zenith positions. Applying an immediate provisionalization and following 1-year in function.

Materials and Methods: Patients identified for single implant treatment in the anterior area were assigned either to the healed site group or the fresh extraction socket group depending on their clinical condition. They underwent a surgical evaluation to secure that they had enough alveolar bone, an intact buccal bone plate (extraction sockets), no major dehiscencies or fenestrations and were suitable for an implant treatment with immediate provisionalization. If the patients were found unsuitable, they were allocated to a third group where they underwent bone regeneration procedures, receiving an implant 4-5 months later.

The patients were rehabilitated with OsseoSpeed™ implants following a drilling protocol in accordance with the manufacturer's recommendations. After confirming initial implant stability, abutments (Direct Abutment™, Profile BiAbutment or TiDesign™, ASTRA TECH Implant System™) were immediately connected to the implant to facilitate immediate provisionalization. Acrylic resin provisional crowns were fabricated and immediately cemented onto the abutment making sure there were no centric or eccentric contact points. Following 8 weeks of healing the provisional crown was removed to allow for impression and 3 to 4 weeks later the patients received their permanent ceramic crown which was cemented onto the abutment.

Periapical radiographs were taken at day of surgery (baseline), 3–4 weeks after implant surgery, at permanent crown placement, 6 and 12 months after implant placement to record changes in the peri-implant hard tissues. Other clinical parameters registered at these follow-ups were papilla height, mucosal zenith score, occurrence of plaque, bleeding on probing and implant mobility. If the implant caused any pain, showed any signs of peri-implant radiolucency or mobility they were considered as failed implants.

For statistical calculations the patient was used as a unit, using Fisher exact test to investigate differences between the two treatment groups with a level of significance set to 5%.

Results: In total 139 patients received 157 implants, however 24 patients did not fulfill the requirements of sufficient bone volume, initial implant stability, or the need to receive immediate provizionalization. Fifty-five patients (58 implants) fulfilled the requirements for immediate implant placement and another 60 patients (65 implants) were allocated to the group for healed sites. Following 1 year in function 4 implants were lost, 3 of which were placed in extraction sockets and 1 placed in a healed site, rendering survival rates of 94.5% and 98.3% respectively. Mean marginal bone remodeling between implant placement and 1-year follow-up was significantly different between the two groups. Implants placed in extraction sockets showed an average bone *gain* of 1.30 mm (SD±2.52) whereas implants placed in healed ridges measured an average bone *loss* of 0.40 mm (SD±1.43). All patients showed good soft tissue health confirmed by low frequencies of both bleeding on probing and plaque occurrence. From the time of definite crown placement and 1-year follow-up the mucosal zenith score showed stable levels or a coronal movement in both treatment groups.

Discussion and Conclusion: In the present study is was shown that immediately loaded single implants, whether placed in extraction sockets or healed ridges gave similar and acceptable survival rates. Only minor changes in the peri-implant hard tissues and modest changes with respect to soft tissue remodeling following 1 year in function, was reported. Midfacial recession have often been reported as a consequence following implant placement in sockets or healed sites, however in this study it was shown that by following a controlled procedural protocol mucosal zenith index stability could be sustained. Further long-term studies are needed and are currently ongoing to further assess the therapeutic approach which may have contributed to this positive tissue response.

Immediate provisionalization of single extraction-site implants in the esthetic zone: a clinical evaluation

Valentini P, Abensur D, Albertini JF, Rocchesani M
Int J Periodontics Rest Dent 2010;30(1):41-51

Purpose: Demands continue to increase for a reduction in healing times and improvements in esthetic outcome for implant supported restorations. To this end much has been reported on the use of immediate loading protocols as well as the placement of implants directly into fresh extraction sockets, with or without the use of regenerative materials depending on the size of the residual socket defect and/or the presence of a dehiscence-type defect. This study was established to monitor success of immediate implants with immediate temporization by virtue of implant survival, maintenance of marginal bone levels and the maintenance of the interdental papilla.

Materials and Methods: Data on implants placed in 90 patients were evaluated. Implants were required to be non-adjacent, placed into fresh extraction sockets and had to achieve a minimum insertion torque of > 40 Ncm to qualify for immediate temporization in order to guarantee adequate primary stability. Presence of local infection was an exclusion criterion although if the infection remitted within one week of extraction under antibiotic therapy implants were then inserted into the still fresh socket. Molar sites were excluded from the study. According to the need for grafting, the time of implant placement (day of extraction or one week later) and the time of provisional prosthesis delivery (which varied from the day of surgery up to 14 days post-op) four groups were established.

Surgical approach varied according to the defect type and the need for augmentation. But in general all teeth were extracted atraumatically and buccal flaps were raised, including adjacent papillae to gain direct access to sockets and associated defects. Osteotomies were located towards the palatal and TiOblast™ implants were typically located with their shoulder 3 mm below the free gingival margin or 2 mm below the adjacent cemento-enamel junction. When implants were due to be immediately temporized, abutment connection was facilitated and these abutments were definitive and not removed again. Grafting was achieved using bovine bone mineral (BioOss) and when indicated covered with a collagen membrane (BioGide). Temporary crowns were fabricated from shells relined over white plastic prefabricated copings. When temporization was delayed a fixture pick-up was used to register the implant position for location in a study cast and laboratory made temporary crowns were then available for insertion 1 to 2 weeks post-op. Healing abutments were located, flaps repositioned and wounds sutured.

All temporary crowns were kept clear of contacts in centric and lateral/protrusive excursions. Intra-oral radiographs were taken at baseline (day of temporization), and one year after delivery of the definitive crown which was delivered typically 3 months post-op. Cumulative Implant survival (CIS), and changes in marginal bone level (MBL) were recorded.

Results: A total of 36 implants were included in the analysis and ranged from 9 to 13 mm in length and 4.0 to 5.0 mm in diameter. Implants were in full function for an average of 2.8 years (range 1–4.1 years). Two implants were removed within 2 weeks post-op. Both these implants were associated with a dehiscence-type defect. The CIS after one year was 95.3%. There were no late failures. MBL measured 0.18 mm mesially and 0.43 mm distally. There were no significant differences between the groups. Visually 78% of implants were associated with complete papilla preservation.

Discussion and Conclusion: This study supports other previous studies in that it corroborates the efficacy and success of this technique. However this study is the first to report on combining the immediate placement with local grafting of dehiscence-type defects. It is worthy of note that the two early failures were both associated with such defects and a history of infection. Nonetheless the study suggests that such cases can in general also be associated with a successful outcome, with excellent maintenance of MBLs, which are typically known to exist with this brand of implant. This in turn was seen to help support a full interproximal papilla in 78% of cases and even some hyperplasia in a further 6% of cases. It can be concluded that while the presence of local infection might jeopardize success, the need for local grafting does not appear to inhibit outcome for immediately placed implants.

Peri-implant tissue response following connective tissue and bone grafting in conjunction with immediate single-tooth replacement in the esthetic zone: a case series

Tsuda H, Rungcharassaeng K, Kan JY, Roe P, Lozada JL, Zimmerman G
Int J Oral Maxillofac Implants 2011;26(2):427-36

Aim: To assess the clinical and radiographic outcome after the immediate placement of an OsseoSpeed™ implant in the fresh extraction socket followed by hard and soft tissue grafting.

Material and methods: Ten patients passed the inclusion and exclusion criteria. Criteria for inclusion were: being over 18 years and signing the informed consent form, having good oral hygiene, having a failing single tooth in the maxilla with healthy neighboring teeth and displaying enough alveolar bone to receive a 3.5x13 mm single implant in the anterior maxillary region. Criteria for exclusion were: a history of smoking, radiation therapy in the head/neck and parafunctional habits or instable occlusion, and lack of primary implant stability at surgery.

A provisional acrylic shell (made from an impression) was fabricated prior to tooth extraction. An OsseoSpeed implant was immediately placed into the extraction socket with an insertion torque between 25–35 Ncm, and the implant-abutment junction leveled 3 mm apical to the buccal gingival margin. A temporary abutment was connected to the implant and the prefabricated shell was relined, adjusted and immediately cemented. Bovine derived mineralized bone substitute was placed in the void between the alveolus and implant. A subepithelial connective tissue graft (SCTG) was harvested through a single incision from the palate. The buccal gingiva at the recipient site was separated from the bone to allow space for the SCTG, which was secured by resorbable sutures. A liquid diet and chlorhexidine rinsing was recommended for the following 2 weeks. Soft diet was recommended for the following 3 months. A permanent zirconia abutment, ZirDesign™, was connected and restored with an all-ceramic crown after 6 months of healing.

The clinical measurements consisted of 6 variables a-f: ***a)*** implant failure according to the criteria by Smith and Zarb 1989; ***b)*** position of the buccal gingival zenith (in relation to a customized stent), measured to the nearest 0.5 mm; ***c)*** clinical mobility (periotest) evaluated at implant placement and 3 months; ***d)*** modified plaque index (Mombelli 1987), signs of plaque (0=no plaque, 1= visible through running a probe, 2= visible, 3= abundance) at 6 sites around the gingival margin; ***e)*** papilla size according to Jemt 1997 (0= no papilla, 1= less than half, 2= half size, 3= perfect papilla, 4= hyper plastic); ***f)*** complications; any adverse reactions in relation to surgical procedures or during follow-up, and technical/prosthetic complications such as occlusal adjustments, repair or screw-loosening.

Marginal bone levels were evaluated from intraoral periapical radiographs, taken by a individualized film holder. The flange of the implant bevel was referred to the reference point and all measurements with bone above this point was considered as ± 0 mm. Bone apical to this point was indicated with a minus before the figure. Bone levels were evaluated at implant placement, 3, 6 and 12 months.

Results: One implant showed signs of infection and was treated successfully by periapical surgery. However, according to success criteria this implant was deemed a failure, although still included in the analysis of marginal hard and soft tissue conditions. The mean level of the gingival zenith was unchanged between pre-surgery and the 12-months follow-up visit. Periotest (measured at implant placement and 3 months) showed significantly more stable implants after 3 months of healing. Plaque index was similar at 3, 6 and 12 months. Papilla fill was unchanged throughout the study (e.g. between implant placement and 12 months). Slightly higher papilla scores were recorded in distal spaces. At 12 months 80% of the papillae scored 2 or 3. Connective tissue graft necrosis was observed in 2 patients who displayed a buccal recession of 1–1.5 mm. Inadequate stability at surgery was noted in 3 cases and was solved successfully by using a larger sized implant. Three technical incidents occurred; 1 loose provisional crown, 1 loose abutment-screw and 1 abutment-screw fracture.

Discussion and Conclusions: This study reported unchanged gingival zenith and maintained papilla fill over the 12-months studied. A proper three-dimensional positioning is a prerequisite for achieving a successful functional and esthetic result, when placing the implant immediately into the fresh extraction socket together with bone substitutes and connective soft tissue graft. The technique described needs to be further evaluated in controlled long-term clinical study set ups.

Osteotome sinus floor elevation without bone grafts – a 3-year retrospective study with Astra Tech implants

Fermergård R, Åstrand P
Clin Impl Dent Rel Res 2012;14(2):198-205

Purpose: Edentulous patients with reduced alveolar bone height in the posterior maxilla are often subjected to augmentation of the sinus floor to be able to receive an implant treatment. The most common surgical procedure, which is quite traumatic for the patient, is to open up a window in the lateral antral wall through which bone graft material is inserted. A less invasive, graftless, method has been developed where the sinus floor is elevated using osteotomes allowing for immediate implant placement. The present clinical and radiographic study was set up to evaluate the outcome of implant treatment in patients subjected to osteotome sinus floor elevation.

Materials and Methods: Thirty-six healthy patients scheduled for implant treatment in the posterior upper jaw and with a bone volume equal to or less than 10 mm in height were consecutively treated with an osteotome sinus floor elevation technique and immediately rehabilitated with a total of 53 TiOblast™ implants. Preparation of the implant site involved the usage of a round bur to penetrate the marginal cortex bone after which the schneiderian membrane and the sinus floor was elevated utilizing concave osteotomes (Ø 2–2,5 and 2,3–3,2 mm) making sure that the sinus membrane was not damaged in the process. Preparation of the marginal bone for implant placement was made with a 3.2 mm straight drill followed by a 4.5 mm conical drill, after which 4.5 mm diameter implants with a length ranging from 9-13 mm were placed in accordance with a 2-stage surgical protocol. After a submerged healing period of 3-4 months, abutment connection was performed and 1 month later the prosthetic constructions were fabricated by the referring dentists (single crowns, fixed partial and full bridges).

All study participants were followed for a 3-year period, with scheduled check-up appointments at abutment connection (radiographic baseline), 1 and 3 years later. Radiological examinations were performed at all scheduled follow-up appointments. Both intraoral as well as panoramic radiographs were used for measuring marginal bone remodeling around the implants and to follow up on the sinus floor elevation respectively. Implant survival rates were also recorded. For an implant to be classified as a surviving implant there should be no signs of periapical bony defects, no signs of major bone loss that could indicate peri-implantitis, no pain caused by the implant and the implant should be in function.

Results: No complications were recorded during the surgical intervention using the osteotome technique and all implants, but one, achieved good primary stability. At abutment connection all implants showed good stability. Two implants were reported lost at the 1-year visit and a third implant was recorded as failed at the 3-year examination, thus rendering an implant survival rate of 96% at the 1-year follow-up and 94% at the 3-year follow-up. All three implant failures occurred in completely edentulous patients.

Radiographic analysis showed a mean height of 6.3 mm (SD±0.3) of the alveolar bone before treatment and a mean elevation of 4.4 mm (SD±0.2) of the sinus floor following the osteotome procedure.

Between abutment connection and the 3 year follow-up the mean marginal bone level change was -0.5 mm (SD±0.08 mm, n=50). The major part of this bone loss, -0.4 mm (SD±0.05 mm, n=51), occurred during the first year of function, whereas only minimal bone loss, -0.1 mm (SD±0.08 mm, n=50), occurred between the 1- and 3-year follow-ups.

Discussion and Conclusion: The present study showed successful and predictable results using an osteotome treatment, in terms of achieving good support for implant placement, without the use of any grafting material. With the use of a conical drill and implants (conical at the coronal part) problem with implant stability could be avoided. There were 3 implant losses during the 3-year study period, all which were inserted in edentulous maxillae, resulting in an cumulative survival rate of 94% following 3 years of function. These results compares well with studies using conventional sinus lift procedures as well as to other studies using the osteotome sinus floor elevation technique.

When considering implant treatment of patients with reduced bone height in the posterior maxilla, this less invasive method could be considered as a viable option replacing the more conventional sinus lift procedures.

Bone formation at the maxillary sinus floor following simultaneous elevation of the mucosal lining and implant installation without graft material: an evaluation of 20 patients treated with 44 Astra Tech implants

Thor A, Sennerby L, Hirsch JM, Rasmusson L
J Oral Maxillofac Surg 2007;65(7 Suppl 1):64-72

Purpose: Traditional sinus lifting techniques have previously been accompanied with various graft materials, however, recent studies indicate that the mere lifting of the sinus membrane in combination with implant placement result in new bone formation. This study aimed to evaluate the bone formation after sinus mucosal lining and simultaneous placement of implants without the use of any graft material.

Materials and methods: Consecutive patient inclusion was performed, and 11 women and 9 men (20 patients, mean age 59 years) fulfilled the criteria of having ≤5 mm subantral bone, and were thus treated with the modified sinus lift method. The surgical treatment started in November 2001 and ended in June 2004, at the University hospital Uppsala, Sweden.

Preoperative sedation (when required) and antibiotics were administered prior to surgery which was performed under local anaesthesia. After a mucoperiosteal flap opening, a rectangular osteotomy was made 5–6 mm cranial to the intended implant site in the maxillary sinus wall. An angulation of the bone cut was made to simplify the repositioning of the bony window. The bony window was carefully dissected, removed and kept in a sterile saline compress. The sinus lift was accomplished in all directions from the entrance window prior to placement of longest possible implants (totally 44, 9–15 mm, ASTRA TECH Implant System™). In order to allow for adequate clot formation around the implants in the sinus, cooling with saline at placement was not performed. In some cases, the drilling procedure was modified by means of the final drilling step. The conical burr was levelled in to the bone 1–2 mm less than recommended, giving a better primary stability using the effect of the conical neck design and the MicroThread™. The establishment of a sufficient blood clot was checked before repositioning the window and suturing of the soft tissue. The patients were given analgesics and antibiotics postoperatively. Additionally, the patients were instructed to use nasal spray saline for 14 days, not to blow their noses, and not to wear the dentures for 7–10 days.

Prosthetic rehabilitation, primarily single crowns, but also a few cases with full arch bridges, was performed by the referring dentist after a mean healing period of 6 months.

Periapical radiographs and orthopantomograms were used for the evaluation of the bone gain around the implants. Necessary adjustments for axial projections were made using the 5.5 mm high MicroThread area as reference.

Result: Perforations of the sinus mucosa at surgery occurred in 11 of the 27 sinus lifts performed. The three largest perforations were sutured while the remaining 8 were so small that further dissection and "tenting" by the implant together with the formation of a blood clot was considered satisfactory. Healing was uneventful in all patients and no infection was observed. Five patients received 1-stage surgery.

One patient lost 1 implant (of 2 inserted) just after abutment placement. No further failures were recorded during the entire follow-up period ranging between 14 and 45 months (mean 27.5 months).

Radiographic evaluation showed a mean gain in bone height of 6.5 mm (SD=2.49 n=44) and a stable marginal bone situation. Two 4.5 mm wide implants in two patients showed a "push out" effect observed already after 3 months. However, the implants remained stable elevated about 2 mm from the marginal bone, throughout the 2 years of follow-up. The regression analysis revealed that longer implants and minimal residual bone resulted in the greatest gain of bone.

Discussion: The approach to restore patients with very thin residual alveolar heights with implants without the addition of graft material have many advantages. No additional graft material is needed, thereby reducing the costs and morbidity possibly associated with harvesting of bone grafts. The technique allows for direct installation of implants avoiding long healing times, which is often the case with grafting techniques. Instead, the new bone is formed simultaneously with the osseointegration process. The TiOblast surface may have properties enhancing the local thrombin and coagulation cascade within the clot (compared to machined titanium) resulting in enhanced revascularization and osseointegration.

In conclusion, the maxillary sinus mucosal lining elevation technique shows an implant survival rate of 97.7%, which is well within accepted survival criteria. Furthermore, the method has profound health-economic advantages including shortened treatment times. As a consequence, the performance of sinus lift with grafting technique has decreased significantly at the mentioned University hospital.

Reconstruction of severely atrophied alveolar ridges with calvarial onlay bone grafts and dental implants

Mertens C, Steveling HG, Seeberger R, Hoffmann J, Freier K
Clin Impl Dent Rel Res; E–pub Oct 20, 2011, doi: 10.1111/j.1708-8208.2011.00390.x

Patients with severely atrophied alveolar ridges are often subjected to bone grafting procedures where autologous bone from intra or extra oral donor sites are utilized to enable their dental implant rehabilitation. Most commonly the iliac crest is used as donor site for this type of augmentation procedures. However, drawbacks such as bone resorption is often associated with this type of grafting material.

Purpose: The approach of this study was to use bone from the calvarium in the reconstruction of the severely atrophied alveolar ridges, followed by implant treatment, with the aim of evaluating survival and success of both implants and grafts.

Matrials and Methods: Fifteen patients with severe and complex alveolar ridge defects were included in the study. To be included the patients were to be in need of a bone graft greater than 5 mm in thickness, which could be harvested from the outer cortex of the calvarium. Four patients received grafts in both jaws, the other 11 patients received graft in the maxilla only.

Under general anesthesia, a block graft was chiseled away (calvarial split bone graft) and segmented in smaller parts after which the donor site was chamfered and closed with sutures. The recipient site, thus received onlay grafts, laterally and vertically, fixated using small titanium screws. For the first three weeks the patients were not allowed to wear their prosthesis. After three months of healing, the patients were subjected to implant treatment given that the graft procedure had been successful (i.e. no signs of infection or exposure, no radiolucent areas at the recipient site, no bleeding at removal of the miniscrews and sufficient bone for implant treatment obtained). In total, the study patients received 99 OsseoSpeed™ implants all placed according to the manufacturers instruction, after applying an alveolar crest incision and the mucoperiosteal flap surgical technique. During implant placement, extra attention was paid to ensure that the implant neck and surrounding bone were leveled. The implants were left to heal submerged for three months after which 10 patients received fixed restorations and 9 patients got removable prosthetic restorations.

Patients were scheduled for follow-up appointments at 6 and 12 months from time of prosthetic loading and then yearly thereafter. Clinical parameters evaluated were; plaque occurrence, bleeding on probing, peri-implant pocket depth, implant stability, bone remodeling and implant success. Patient satisfaction concerning both donor-site surgery as well as implant treatment was taken into consideration.

Results: No donor site complications, pain or morbidity were reported. In the early healing phase, there were two grafts showing signs of infection which led to partial removal of the graft but thereafter the healing could be resumed without further complications. Radiographic graft success was 100%, according to the criteria by Barone et al. 2007. All study participants could undergo implant treatment and all 99 implants reached primary stability. During the submerged healing phase, two implants failed to osseointegrate rendering a cumulative survival rate of 98%. Five implants did not fulfill the success criteria by Albrektsson 1986, thus giving a success rate of 95%. In addition, a 100% prosthetic success and no technical adjustments were reported. Following the mean observation period of 28 months, a mean marginal bone loss of 0.5 mm (SD±0.6) was registered. Good oral hygiene was recorded for 79% of the implant sites, 17% showed bleeding on probing, and the mean probing depth was 3 mm. Patient satisfaction was very high with respect to donor and recipient site surgery as well as to implant treatment.

Discussion and Conclusion: The current study presents calvarial bone grafts as a successful treatment alternative to iliac bone grafts when treating patients with severely atrophied alveolar ridges. Low morbidity at the donor site and stable marginal bone levels rendering good prerequisites for implant rehabilitation was achieved. Hence, implant rehabilitation could be performed with good primary stability and the patients, followed for 1 year, scored "very satisfied" when asked for their opinion in regards to function, esthetics and over all satisfaction.

Clinical evidence
I. Restorative solutions

The ASTRA TECH Implant System™ has been clinically documented when used to support a wide range of restorative solutions. This section is dedicated to the published clinical evidence supporting the treatment outcome using various standard and advanced restorative solutions.

Restorative solutions

Advanced restorative solutions

Related reading:

Fixed full bridge solutions 59, 62
Single tooth 48, 60
Overdenture solutions 44, 56

Implant rehabilitation of the atrophic edentulous maxilla including immediate fixed provisional restoration without the use of bone grafting: a review of 1-year outcome data from a long-term prospective clinical trial

Toljanic JA, Baer RA, Ekstrand K, Thor A
Int J Oral Maxillofac Implants 2009;24(3):518-26

The immediate restoration of implants placed into the edentulous maxilla has received some attention with the literature providing supporting evidence for high success/survival outcomes as measured by implants retained in function over the short-term. However there is still a need for further study in this area particularly for treatment of the atrophic maxilla where low bone volume and density might result in a compromised outcome.

Purpose: This study therefore set out to monitor the success/survival of implants placed into atrophic maxillae and subject to immediate restoration as part of a long-term prospective study.

Materials and Methods: Twenty-four men and 27 women with atrophic edentulous maxillae scored as C, D or E according to the Lekholm & Zarb classification and with a bone quality scored as either 3 or 4 were consecutively enrolled to the study in two different centers. Selected implant sites had to be capable of receiving at least an 8 mm x 3.5 mm implant without the need for bone grafting. Patients who had uncontrolled disease either locally or systemically or who smoked were excluded as were any patients who had received earlier bone grafting procedures.

All patients were treatment planned to receive 6 OsseoSpeed™ implants placed via a conventional approach. The drilling protocol was adjusted to allow for low density bone, resulting in under-preparation where necessary, so the self tapping implants could attain a higher degree of primary stability. When necessary the most distal implants were angulated to avoid any breach into the sinus cavities. Where buccal dehiscences occurred, exposing threads, no action was taken to cover the threads since grafting was not part of the study protocol. Straight or angulated abutments were connected at time of surgery and appropriate copings secured to them prior to repositioning of the flaps for suturing. Screw-retained prostheses were fabricated by either a direct or indirect technique. For the former, the patient's own existing denture was trimmed, hollowed and relined in situ over the copings to allow a direct pick-up. For prostheses fabricated via the indirect route, an abutment level impression was taken and a previously prepared tooth set-up was located to the master cast and processed around the copings. Prostheses were finished according to standard techniques. All prostheses were delivered within 24 hours.

Data on implant dimensions, site location, bone density and volume were all recorded as was primary stability measured by peak insertion torque values (PIT, Ncm). Standardized radiographs were taken using a paralleling device to measure the bone level under x7 magnification and to the nearest 0.1 mm relative to the bevel at the top of the implant. At 12 weeks post-op all restorations were removed to allow the fabrication of the definitive prostheses. At this time implants were individually assessed for osseointegration and radiographs taken. Definitive prostheses were inserted approximately 22 weeks after surgery when another set of radiographs were taken. At 12-months post-op patients were once again recalled for removal of prostheses to allow direct implant assessment and for additional radiographic evaluation.

Results: A total of 306 implants were inserted into bone which was relatively evenly classified between categories C & D and between qualities 3 and 4. PIT values ranged from <10 to >45 Ncm (50% 0 – 25 Ncm). 25 patients were provisionalized via the direct method. There was 1 patient drop-out and a total of 12 implants (5 patients) were deemed failures within the 12-week provisional period (4%). At time of definitive prosthesis placement there was a mean bone loss of 0.5 mm +/- 0.7 mm with no additional bone loss noted at the 1-year recall. No single parameter could be identified as being associated with the failures.

Discussion and Conclusion: The data from this 1-year interim report would seem to suggest that even implants placed into the atrophic maxilla without the use of any bone grafting can be successfully restored and placed into immediate functional loading, with survival data and marginal bone loss data being comparable to that reported elsewhere. This may present a more appealing treatment strategy to patients with little apparent additional risk.

A 2-year prospective study on immediate loading with fluoride-modified implants in the edentulous mandible

Collaert B, Wijnen L, De Bruyn H
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In recent years advances with respect to development of implant surfaces has occurred promoting successful rehabilitation with dental implants. The OsseoSpeed™ implant is an implant with a fluoride-modified surface which has proven to facilitate faster and stronger osseointegration in animal as well as in clinical studies.

Purpose: The present prospective study was aiming at showing results of implant survival and marginal bone remodeling after placement of 5 implants and subjecting them to an immediate loading protocol to restore completely edentulous mandibles. The implants were followed for 2-years.

Materials and Methods: In total, 25 patients were enrolled in the study, all in need of a full jaw rehabilitation in the mandible. Patients with insufficient bone volumes unable to receive an implant with the length of 8 mm and width of 3.5 mm were excluded from the study. In the case of any remaining teeth in need of extraction a healing period of at least 4 months were applied from time of extraction before any implant treatment could start.

All patients received five OsseoSpeed implants in the mandible, placed between the mental foraminae to support a full screw-retained restoration with a maximum of 2 cm bilateral, distal cantilevers (figure 1). A surgical template, based on the patients existing denture, was used for correct implant placement. A full-thickness flap technique was applied, preparing the implant site in a way to ensure that the implant shoulder was supported by surrounding bone. No grafting with bone regenerative materials were performed. Immediately after implant placement Uni Abutments with a height between 0–4.5 mm were seated onto the implant. Impressions were taken, using closed trays, to prepare for fabrication of a provisional, screw-retained bridge to be connected the next day. After 3 months from implant insertion the provisional bridge was removed, abutments were torqued to 20 Ncm and the final screw-retained metal ceramic or metal resin reconstruction (10–12 teeth) were fabricated by the referring dentist.

Mesial and distal bone remodeling was assessed through intraoral radiographs taken at day of surgery (baseline), 3, 6, 12 and 24 months following implant placement. The patient was used as a unit where a mean value of bone-to-implant contact level for all 5 implants was calculated. After 24 months of function the bridge was removed to check for implant stability, peri-implant pocket depth and bleeding on probing. An implant was deemed successful if, after 24 months, the bone loss was less than 1 mm, no apparent signs of pain or mobility, no neuropathy or persistent parasthesia and no signs of peri-implantitis (success criteria according to De Bruyn & Collaret 2008).

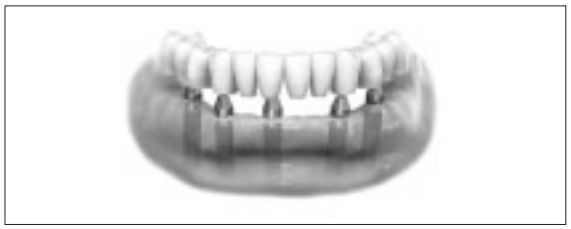

Figure 1. Schematic illustration of the implant treatment concept in this study. Five intra-foraminal OsseoSpeed™ implants (straight or conical shape) were supporting a provisional/ permanent screw-retained fixed full bridge with cantilevers, from day 1 after surgery.

Results: Twenty-five patient were rehabilitated with 125 OsseoSpeed implants. In 3 patients the insertion torque was <10 Ncm, despite this, none of the implants or prostheses failed during the 24-month observation period, rendering a survival rate of 100%. No signs of peri-implantitis were detected with a mean peri-implant pocket depth of 2.46 mm. However, bleeding on probing was observed in almost all patients, and detected in 82% of the implant sites. None of the patients showed any signs of neuropathy or parasthesia. In addition, none of the implants lost more than 1 mm of peri-implant bone, hence, all implants fulfilled the success criteria in this study, leaving a 100% success rate. There was a significant mean marginal bone loss of 0.14 mm between baseline and the 3 month follow-up, however, following 6 months and onwards the bone level remained unchanged with a mean marginal bone loss on patient level following 24 months in function of 0.12 mm (SD±0.14).

Discussion and Conclusion: This prospective study successfully shows that immediate loading of fluoride-modified dental implants can provide a predictable implant treatment for patients in need of screw-retained restorations of the edentulous mandible. The present study showed high survival and success rates during the 2-year observation period with limited mean marginal bone loss and no signs of peri-implantitis.

Bone level change at implant-supported fixed partial dentures with and without cantilever extension after 5 years in function

Wennström J, Zurdo J, Karlsson S, Ekestubbe A, Gröndahl K, Lindhe J
J Clin Periodontol 2004;31(12):1077-83

Purpose: This retrospective study set out to analyze the effect of cantilevers on marginal bone levels at implants supporting freestanding fixed partial dentures (FPDs).

Materials and Methods: Fifty-one periodontally compromised patients were restored with a total of 56 FPDs supported by ASTRA TECH Implant System™. All patients had undergone a comprehensive periodontal program before, during and after implant reconstruction. Of the total series 6 FPDs had less than 5 years follow-up, 3 FPDs were in patients lost to follow-up and a further 3 FPDs failed as a result of implant failure two of which had cantilever units. Thus 50 FPDs were available for radiographic analysis. Of these 24 had cantilever extensions (Group C) and 26 did not (Group NC). All FPDs were screw-retained and a classic healing and two-stage surgical protocol was employed. The two groups were comparable for age, number of remaining teeth, prevalence for smoking, and number of supporting implants which was 2.6 as a mean for the cantilever group and 2.8 for the non-cantilever group. For group C, 16 FPDs were maxillary and 8 were mandibular compared to 12 and 14 respectively for group NC. The mean number of units per FPD was 4 for group C and 3 for group NC.

Cantilevers were on average 9.0 mm long. Three cantilevers were kept clear of the occlusion. Radiographs of each implant were obtained using standardized long cone radiographs in customized film holders. Baseline radiographs taken at prosthesis insertion were compared to those taken at the 5-year follow-up. Bone levels were recorded with respect to the implant-abutment junction. Marginal bone levels were analyzed at the FPD level, the implant level or the surface level (i.e. the distal surface of the most distal implant related to the cantilever or absence thereof.)

Statistics was performed by the use of a bivariate analysis (Mann-Whitney U-test) and a stepwise regression analysis utilized to evaluate influence of confounding factors on the longitudinal peri-implant bone level change.

Results: For the pooled data the mean marginal bone loss (xMBL) measured 0.4 mm. The xMBL for maxillary FPDs measured 0.6 mm compared to 0.2 mm for the mandible, ($p < 0.05$). The xMBL for implants in group C measured 0.49 mm compared to 0.38 mm in group NC. The bone loss at the most distal surface of the distal implant in both groups measured 0.35 mm and 0.22 mm respectively. 33% of the implants in group C recorded a bone loss of >1.0 mm compared to only 19% in the NC group. None of the above results demonstrated any significant difference.

When stepwise regression analysis was used, the only factors that appeared to influence longitudinal bone changes was smoking and treated jaw.

Discussion and Conclusion: In this retrospective cohort study with a 5-year follow up, the inclusion of a distal cantilever did not appear to negatively influence marginal bone loss data whether considered at the FPD level, the implant level or more importantly at the level of the implant surface facing a cantilever. However data did reveal a tendency towards small increases in marginal bone loss for implants supporting cantilever prostheses. This might be a reflection of the fact that a greater proportion of FPDs in group C were maxillary and as such may not have been a reflection of the presence of a cantilever at all. The only other related influential factors on longitudinal bone levels was smoking and treated jaw. The overall mean peri-implant bone level change over 5-years in function was 0.4 mm, which is by all standards very small. Only 6 technical complications were recorded, equally distributed between the two groups.

In conclusion, the findings in the present study show that inclusion of cantilever extensions in patients with good oral hygiene and well performed occlusion (of the prosthesis) may not jeopardize the long-term prognosis of the ASTRA TECH Implant System supported FPDs.

Comparison of three-implant-supported fixed dentures and two-implant-retained overdentures in the edentulous mandible: a pilot study of treatment efficacy and patient satisfaction

De Kok I, Chang K-H, Li T-S, Cooper LF
Int J Oral Maxillofac Implants 2011;26(2):415-26

Purpose: The purpose of this study was to evaluate the rehabilitation of the edentulous mandible in terms of implant survival rate, prosthetic outcome and patients satisfaction in patients treated with either two-implant supported overdentures (OD group) or three-implant supported fixed full bridges (Bridge group).

Materials and Methods: A prospective, randomized, controlled study design (RCT) was applied at a single study centre (University of North Carolina, US). Twenty patients who signed informed consent and passed general inclusion and exclusion criteria, were randomly assigned to either of the treatment modalities. Prior to any treatment, the patients filled in a baseline questionnaire related to their quality of life and general satisfaction/opinion of their current dentures before they were provided with completely new dentures in both the mandible and maxillae (see table). The same questionnaire was filled in a second time at the 1-year visit.

Functional limitation	General satisfaction
Physical pain	Comfort
Physical disability	Esthetics
Psychologic discomfort	Retention
Psychologic disability	Stability
Social disability	Ease of cleaning
Handicap	Ease of chewing
	Ease of speaking
OHIP variables scored by the patient before and 12 months after the treatment to evaluate quality of life. Scores were 0 = never, 1 = hardly, 2 = occasionally, 3 = fairly often, 4= very often	**V**isually **A**nalog **S**cale of variables rated by the patient before and 12 months after the treatment, to evaluate the patients opinion on their dentures. Scale was 0–100 mm, 0 = very bad; 100 = perfect

Presurgical planning included extra care to identify anatomical landmarks on the CT slides. Overdenture patients received 2 implants and bridge patients received 3 OsseoSpeed™ implants, placed between the mental foramina in a 1-stage approach. Ball abutments were connected to the implants in both groups, and the flaps were sutured around the abutments. The newly provided mandibular overdenture was relived in the area of the abutments and relined to provide immediate provisialisation during the healing period. Patients were advised to rinse with chlorhexidine for 2 weeks and were scheduled for postoperative check-ups.

Preparation of the definitive prosthesis started after 8 weeks of healing. By standard prosthodontic procedures overdentures were provided with Clix attachments (Prexi Clix, Preat) to retain the overdenture to the securely torqued ball abutments. The fixed bridges were produced via implant level impression, CAD/CAM milling of the framework (U-Best, Dental Technology) and screw-retained to Uni-Abutments. Definitive permanent loading took place within 16 weeks post-surgery. Follow-up visits took place at 6 and 12 months, where soft tissue health, implants stability, x-ray, implant and prosthetic complications were recorded.

A per protocol analysis was undertaken, descriptive statistics presented and independent and the paired t-test was used for the comparisons between, respectively, within groups.

Results: There were 9 men and 11 women, with a mean age of 62,5 years, included in this study and followed for 1-year. Demographic data did not differ between the groups. All implants and all prosthesis survived, resulting in 100% implant and prosthesis survival, respectively. Healthy soft and hard tissues, and no pain or mobility was recorded throughout the study. Few technical complications occurred (2 incidents of loose ball abutments, 1 loose bridge screw and 3 repair of denture teeth), however, some denture adjustments were made due to discomfort.

Patient's opinion about their prosthesis (VAS evaluation) improved significantly in both groups, in all categories, between baseline and 12 months. Comparison between the groups revealed no significant difference at baseline and only the ease of cleaning was scored higher (better) in the overdenture group at 12 months. Patient's quality of life (OHIP evaluation) improved significantly in both groups, in all categories, between baseline and 12 months. Comparisons between the groups revealed no difference in any category neither at baseline nor at 12 months.

Discussion: This randomized trial sought to reveal patients satisfaction, implant and prosthesis survival of 2-implant supported overdentures and 3-implant supported fixed full bridges after 1 year of use. No implant or prosthetic reconstruction failure occurred, and the patients were very and similarly satisfied with both treatment regimes. If a 3-implant supported fixed bridge comply with long-tome functional use, needs to be further evaluated.

Immediate functional loading of implants in single tooth replacement: a prospective clinical multicenter study

Donati M, La Scala V, Billi M, Di Dino B, Torrisi P, Berglundh T
Clin Oral Implants Res 2008;19(8):740-487

Single-tooth implants have been variously reported to show high success rates both when benefitting from a delayed period of healing for osseointegration and when immediately temporized but without immediate functional loading. Only few studies have presented data on immediate functional loading of single-tooth implants (STI).

In conjunction with immediate loading of implants there has been data presented on the benefits of using an osteotome technique for lateral bone condensation to increase peri-implant bone density and the bone-to-implant contact thereby increasing primary implant stability.

Purpose: This immediate load study aimed to compare the use of an ostetome and drilling protocol for the placement of STIs (ASTRA TECH Implant System™ 4.0 mm and 4.5 mm Ø) in a prospective randomized controlled manner.

Materials and Methods: Seventy male and 81 female patients with good general health were enrolled to the study. Smokers represented 23% of the study population with 11% smoking >10 cigarettes per day. These patients were evenly distributed amongst the groups. All patients had one tooth missing for at least 3 months, with healthy adjacent teeth. A minimum criterion of 20 Ncm was required as an insertion torque and no indication for grafting was allowed. Patients were randomly allocated to one of three groups. Group 1 acted as control (n = 57) where implants were inserted using a standard drilling protocol according to manufacturer's recommendations, submerged for undisturbed healing, and exposed after 3 months for restoration and functional loading. In group 2 (n = 50) patients also benefitted from the same standard drilling protocol but implants were placed into immediate functional load while in group 3 (n = 54) osteotomy preparation was via a modified technique using first a 2.5 mm diameter drill followed by osteotomes of increasing diameter to widen the preparation, with implants placed into immediate functional load.

In order to fulfill the requirement of immediate functional loading for groups 2 and 3, an impression pick-up of the implant was made at the time of surgery and a customized abutment and temporary acrylic crown fabricated within 24 hours. Definitive abutments were tightened to 20 Ncm and the temporary crown cemented with Temp Bond. Crowns were placed into centric occlusal contact. After 3 months the implants in the control group 1 were exposed and restored with customized abutments and temporary acrylic crowns. After a further 3 months of functional loading all implants were subject to new impressions and definitive ceramo-metal crowns were delivered.

Patients were recalled at 3 and 12 months for assessment of plaque, probing depth and mucositis scores as well as measurement of the width of keratinized tissue and the papilla length on the mesial and distal of each implant-retained crown.

Standardized intra-oral radiographs taken with a paralleling technique were evaluated by an experienced, blinded radiologist at baseline (insertion) and at 3 and 12 months follow-up to assess the level of the marginal bone relative to the implant-abutment junction. Comparisons between groups were analyzed statistically.

Results: Three implants in group 3 failed to osseointegrate (5.5%), while one implant in group 2 failed to integrate (2%). Periodontal parameters were comparable between the groups except for probing depth of 4–5 mm on the distal aspect of group 1 implants which was significantly higher than for groups 2 and 3, $p < 0.05$.

When comparing radiographs there was a notable difference between group 3 and the other two groups with less marginal bone loss, although this did not reach significance. However when considering the frequency of implants which lost > 1.0 mm there was a significant difference between groups 2 and 3 compared to the control group 1, $P = 0.01$. Additionally there was a significant difference in the outcome for 4.0 mm ø implants compared to 4.5 mm ø, in favor of the former which showed less bone loss, $p < 0.05$. When considering treatment protocol and implant diameter as co-variables the analysis revealed a highly significant difference for increased bone loss at 4.5 mm ø implants placed using a conventional surgical protocol, $p < 0.01$. Other variables such as sex and smoking status had no influence, while location was influential, $P = 0.04$.

Discussion and Conclusion: Until now no data appears to be available using both an osteotome technique and immediate functional loading for single tooth implants. The data in the current study is broadly comparable with that of other studies, in that the outcome measures from clinical and radiographic parameters are similar to that achieved with a conventional protocol. In the current study implants lost the majority of bone between baseline and 3 months with little additional bone loss thereafter. This too is in agreement with previous studies. The finding that more bone loss was observed at 4.5 mm ø implants is not currently explained, although one can postulate about the influence of primary stability issues and implant geometry, however the marginal bone levels recorded at the 4.5 mm ø implants are similar to those recorded by Cooper and Norton for early and immediate restoration protocols.

The higher failure rate of implants subject to immediate loading is of concern, in particular for 5.5% in group 3 where an osteotome technique was used. It has been proposed that this technique results in trabecular fractures which do not occur when using a drilling protocol. This may require further consideration.

Astra Tech single-tooth implants: an audit of patient satisfaction and soft tissue form

Palmer RM, Farkondeh N, Palmer PJ, Wilson RF
J Clin Periodontol 2007;34(7):633-8

Purpose: One area that influences the patient satisfaction scores for implant treatment is the interdental papilla form and the factors that determine its presence, absence or degree of fullness. Different studies have reported differing methodology but in general the results would indicate that implants are less capable of retaining a full papilla compared to natural teeth.

This study set out to determine patient satisfaction levels with single-tooth implants and to compare these scores to a rating by the clinician in light of papilla fill and marginal bone levels, as well as to consider the relationship between the two.

Materials and Methods: Sixty-six patients treated for single-tooth replacement in the anterior maxilla were enrolled to the study. All implants had been in function for a minimum of 12 months. Patient questionnaires were completed as part of their recall program with a scale of 1 to 6 to score each parameter from extreme dissatisfaction to total satisfaction. Parameters included crown form and color, masticatory and phonetic function, comfort, and ease of care. In addition, 4-site pocket depths were recorded along with a score for the papilla fill (Jemt index) where 0 = no papilla to 4 = papillary hyperplasia.

Intra-oral radiographs were taken using a Rinn device for standardization. In order to identify contact points (CP), fine orthodontic wire was tightened around each contact to allow accurate measurements of both vertical and horizontal distances taken from the first bone-to-implant contact to the contact point fBIC-CP, the peak of periodontally sound bone adjacent to the natural tooth to the contact point, pBNT-CP, implant shoulder (IS) to fBIC as well as the horizontal distance from the shoulder of the implant to the adjacent tooth, (HD). Results were subject to both paired and two-group t-tests as well as the Mann-Whitney-U test.

Results: Sixty-six patients all scored their crowns as a 6 for color and form compared to a score of 4.5 – 5.5 as scored by the clinicians, ($p < 0.001$). With respect to function all patients again scored 6. Twenty crowns were devoid of contact points thereby excluding them from the radiographic analysis, but all these crowns were associated with normal looking papillae. For the other 46 crowns almost 50% of papillae received a score of 2 and 50% received a score of 3 (ideal). No papilla scored 0 or 4. Probing revealed mean pocket depths of 2.63 mm at implants compared to 2.09 mm at teeth, ($p < 0.001$).

Radiographic analysis revealed that the mean of the mesial and distal median distances for fBIC-CP measured 9.3 mm for a papilla score of 2 and 7.7 mm for a papilla score of 3. The average distance for pBNT-CP measured 6.58 mm for a papilla score of 2 and 5.26 mm for a score of 3. HD measured 2.6 mm for a papilla score of 2 and 1.85 mm for a score of 3. The distance IS-fBIC measured 0.0 mm in most circumstances as bone was at the reference level. The differences between values for papillae with a score of 2 and 3 were highly significant on the mesial side only, (tooth $p < 0.001$; implant $p = 0.002$). There was a highly significant difference between distances of IS-CP in favor of the distal surface of implants which gave the impression that radiographic distance for bone levels was better on the distal side.

Discussion and Conclusion: The current study provides conclusive evidence that there is a high chance of fulfilling patient's expectations with a single-tooth implant, with patient satisfaction scoring consistently higher than the clinicians. This corroborates previous studies.

With respect to papilla fill as it relates to peak bone levels, previous studies have lacked clarity, with techniques such as bone sounding yielding imprecise data. This study utilized a novel technique for imaging the contact point so that accurate and reproducible measurements could be made radiographically.

These data reveal a similar trend to that already proposed but with slightly different numbers. In the current study a papilla score of 3 (ideal) could be achieved when the critical CP- pBNT distance measured 6 mm for teeth, or when the CP- fBIC measured 8.5 mm for implants, at the 95% confidence interval. These values are greater than those proposed by Tarnow et al, whose 5 mm rule is universally adopted, where some loss of papilla would be expected at 6 mm. In addition no influence was found on the horizontal distance between teeth and implants, with bone being retained at the implant reference level in almost all sites. This may be related to implant design.

The finding that distal values were smaller was significant and this may be due to a more apically located contact point as has previously been proposed. This was confirmed through radiographic measurements of the distance IS – CP, which indicated that the distal CP was typically 1.5 mm more apical than the mesial CP. This may have an impact on papilla form although there was no significant discernable difference between mesial and distal papilla fill in the current study.

A prospective 3-year study of fixed bridges linking Astra Tech ST implants to natural teeth

Palmer RM, Howe LC, Palmer PJ
Clin Oral Implants Res 2005;16(3):302-7

Purpose: The purpose of this study was to evaluate the clinical and radiographic outcome of both teeth and implants used to provide combined support for 3-unit fixed partial dentures.

Materials and Methods: Twenty-one patients were recruited for the restoration of free-end saddles using the most distal natural abutment and an implant placed distal to that. All natural abutments were periodontally healthy.

In 13 cases the implant was placed such that there was a middle pontic but in 6 cases the pontic was cantilevered distally and the implant was placed directly adjacent to the natural abutment.

A total of 21 implants (ASTRA TECH Implant System™ ST 4.5 mm) were placed according to a conventional protocol and were either 9 mm (n = 2), 11 mm (n = 11) or 13 mm (n = 8) in length. Subsequent to abutment connection impressions were taken with the natural abutment prepared to accommodate a gold telescopic coping. An implant-head impression was also captured so that the technician could prepare a Profile BiAbutment parallel to the telescopic coping on the natural tooth. A composite-gold suprastructure was then fabricated on a master model of the copings in situ and these were secured with temporary cement.

Follow-up radiographs were taken using customised holders for the paralleling technique and standardization. In addition plaque scores, bleeding on probing and probing depths were recorded.

Radiographs were evaluated by an independent examiner at x7 magnification, to the nearest 0.1 mm. Marginal bone levels were measured with respect to the reference point at the top of the implant and the crown margin on the natural tooth. Tooth intrusion was also measured. Results were subject to statistical analysis.

Results: Two patients were lost to the study each with a middle pontic design and the results are therefore expressed for the remaining 19 patients.

There were no implant failures and all prostheses remained in functional occlusion. Plaque scores increased from baseline, $p < 0.02$ however this was not reflected in changes for bleeding on probing. Probing depths also increased from baseline, $p < 0.001$.

With respect to marginal bone levels the 3 year data revealed an increase in bone loss of only 0.13 mm at the implants and 0.39 mm at the natural teeth. These changes were not statistically significant. The frequency of no bone loss at implants was 53% and at teeth was 42%.

The commonest complication was bridge decementation (42%) and in one site a loose abutment screw was detected. Composite fracture or chipping was also recorded for 8 bridges, necessitating repair. No tooth intrusion was noted.

Discussion and Conclusion: In this prospective study it was possible to demonstrate the efficacy of connecting a ST implant to a single healthy natural abutment to support either a cantilever or mid-pontic 3-unit fixed partial denture. Implants and teeth remained immobile, with insignificant changes in the marginal bone levels. There was no evidence of tooth intrusion. Prosthetic complications were mainly restricted to decementation, which was addressed by using a mid-strength cement and composite fracture, which necessitated occlusal refinements and repair. The technique helped to avoid additional sinus graft procedures.

Clinical evaluation of immediate loading of electroeroded screw-retained titanium fixed prostheses supported by tilted implant: a multicenter retrospective study

Acocella A, Ercoli C, Geminiani A, Feng C, Billi M, Acocella G, Giannini D, Sacco R
Clin Impl Dent Rel Res; E-pub Oct 2011, doi: 10.1111/j.1708-8208.2011.00379.x

Purpose: This retrospective study set out to investigate the long-term effect of OsseoSpeed™ dental implants when placed in parallel or tilted in the edentulous mandible and subjected to immediate loading using screw-retained, electroeroded cast-titanium fixed prosthesis.

Materials and Methods: Patients in need of full dental implant rehabilitation in the mandible were informed of two treatment alternatives; receiving an implant treatment with conventional, 2-stage submerged healing or immediate loading protocol, i.e. 1-stage surgery. Only patients choosing the immediate loading regime and treated with 2 tilted and 3 upright OsseoSpeed implants supporting an electroeroded definitive cast-titanium screw-retained prosthesis were included in the study. Patients with uncontrolled diabetes, radiation treatment to head or neck, pregnant women, patients subjected to bone grafting at the planned implant site, having poor oral hygiene or showing lack of motivation were excluded from the study.

The surgeon placed releasing incisions to be able to raise a mucoperiosteal flap, granting access to the alveolar bone. Positioning of the distal implants, which were tilted 20–30° in a posterior direction took place first, followed by the medial implant and the two others. The manufacturer's instructions were followed when preparing the osteotomies, where a minimum insertion torque of 35 Ncm had to be reached. All implants were placed intraforaminal. Abutments were 20° Uni-Abutment also from ASTRA TECH Implant System™. After closing the flap with sutures an impression was made for the fabrication of the prosthesis. Using grade 1 commercially pure titanium, a 1-piece, complete arch, screw-retained framework was casted followed by electroerosion for improved prosthesis fit. The Sheffield test was used to confirm improved/passive framework fit. Resin teeth were used for the definitive mandibular prosthesis, which was delivered within 48 h from time of implant surgery.

At each follow up, the first occurring 3 months after loading and then at least yearly thereafter, the prosthesis was removed and implant stability, presence of pain, parasthesia, implant probing depth, bleeding on probing and/or suppuration was evaluated and radiographs were taken. Prosthetically related complications were also recorded. Differences in bleeding on probing and probing depths between tilted and non-tilted implants were evaluated using paired t-test, α=0.05.

Results: In total, 225 OsseoSpeed dental implants were placed in 45 patients. During the 4-year investigation period 2 implants failed to osseointegrate (one tilted and one nontilted) rendering a cumulative survival rate of 99.1%. By applying the electroerosion technique to the framework the interfacial gaps between the abutment and casting of the prosthesis could be reduced in all cases with no further need of adjustments. There was no signs of pain, or peri-implant infection during the investigation, other than in conjunction to surgery. Extensive wear of the acrylic teeth was seen in 11 patients and 3 patients showed fracture of the veneering resin, which needed repair. In total a 4-year prosthetic survival rate of 97.8% was reported.

Analysis of the peri-implant probing depth and the bleeding on probing showed that tilted implants had significantly higher values as compared with implants placed upright.

Discussion and Conclusion: The study aimed to assess clinical and prosthetic outcome of fixed full bridges supported by 2 tilted and 3 parallel implants in the edentulous mandible. A null hypothesis was set up, that there would be no difference in clinical variables between the tilted and nontilted implants. Evaluation of bleeding on probing and probing pocket depth after 4 years in function rejected the hypothesis, although implant survival were similar in both groups. Within the limitation of this retrospective study, it could be concluded that immediate loading of 5 implants (whereof 2 tilted) used as support of a full-arch electroeroded screw-retained titanium fixed prosthesis provides a reliable treatment option for the rehabilitation of the edentulous mandible.

Mandibular overdentures supported by 6-mm dental implants: a 1-year prospective cohort study

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Clin Impl Dent Rel Res; E–pub Jul 13, 2011, doi: 10.1111/j.1708-8208.2011.00358.x

Aim: The benefit of placement of 2 standard length implants after a bone augmentation procedure versus the placement of shorter (≤10 mm) implants in the available bone to retain an overdenture is debated in the literature. The objective of this study was to assess the clinical outcome of four 6 mm long implants supporting an overdenture in the atrophied mandible.

Material and methods: Patients were eligible for inclusion in the study when being edentulous in upper and lower jaws and fulfilling mandibular resorption class VII–VIII, having a mandibular symphysis height between 6–8 mm and a width of at least 6 mm (detected from cepfalometric radiographs). Exclusion criteria were abundance of soft tissue in the interforaminal region, history of implant treatment in the mandible and history of radiotherapy in the head and neck region.

Implant placement was performed through an open flap procedure after the exact localization of the mental foramina. The 2 distal implants were placed bicortically and at least 5 mm anterior of the mental foramina. The medial implants were placed so that the distance between all the implants were as equal as possible. The implant used was 6 mm long and 4 mm wide, OsseoSpeed™ 4.0S. Forty-eight implants were placed in 12 patients. Loading was not allowed until 2 weeks after implant surgery when relining of the existing denture took place. After 3 months of submerged healing, Healing Abutments were connected, which were replaced after another 2 weeks by 20° UniAbutments. The implants were splinted by an egg-shaped bar to which the overdenture was connected by gold clip attachments. The patients were instructed in how to perform oral hygiene.

Implant survival was monitored through the study period. Change in marginal bone height from implant placement to the 1 year follow-up was assessed (orthopantomograms) as were clinical conditions such as plaque index (Mombelli), presence of calculus (yes or no), gingival index (modified Löe and Silness), bleeding index (Mombelli) and probing pocket depth. Patient's satisfaction was evaluated before treatment started and at the 1 year follow-up visit. Any surgical or prosthetic complications were recorded.

Descriptive statistics were calculated and comparisons evaluated by paired Studen's t-test at a significant level of 0.05.

Results: All patients were able to complete the 1-year follow-up visit. Two implants failed giving a cumulative implant survival rate of 96%. The two patients with a failed implant, reported pain from the area within 2–3 weeks after surgery. The reason for failure was lack of primary stability in one case and in the other case a mandible fracture. In both cases the implants were removed without replacement and the area healed without further complications. No other surgical or prosthetic complications occurred. The mean bone loss between implant placement and 1-year was 0.1 mm (SD 0.3). Clinical parameters showed that excellent oral hygiene had been established. Mean probing depth was 3.4 mm (SD 1.3), plaque index 1.4 (SD 0.6), Calculus index 0.4 (SD 0.4), Gingival index 0.5 (SD 0.5) and bleeding index 0.6 (SD 0.4) at the 1 year visit. The patients expressed a significant improvement in their functional assessment of their dentures, esthetics and over all satisfaction between baseline and 1-year.

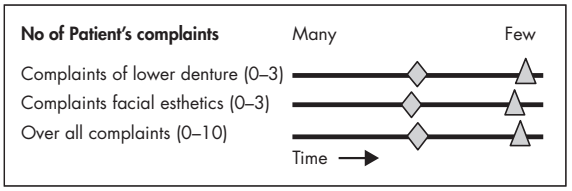

Figure 1. Functional complaints of lower denture and facial esthetics was graded on a 0–3 scale, and overall satisfaction on a 1–10 scale. ◇-symbol show pre-treatment value and △-symbol show value after 1 year.

Discussion and Conclusions: This study shows that four 6mm short OsseoSpeed implants, placed in the atrophied mandible can support a bar retained overdenture. The study period was rather short, only 1-year, however, no complications occurred after time of loading. Patients were well motivated and were able to hold a high oral hygiene control.

Clinical and radiographic evaluation of early loaded narrow diameter implants – 1-year follow-up

Galindo-Moreno P, Nilsson P, King P, Becktor J, Speroni S, Schramm A, Maiorana C
Clin Oral Implants Res; E-pub Nov 19, 2011, doi: 10.1111/j.1600-0501.2011.02254.x

Purpose: To evaluate the clinical outcome of narrow Ø 3 mm OsseoSpeed™ implants placed in the upper lateral and lower incisal positions, by a one-stage surgical protocol and subjected to early loading.

Material and Methods: This prospective, international, multicenter study allowed patients for inclusion if they were healthy, smoked less than 10 cigarettes/day, and had a single tooth loss in upper lateral or lower incisor position provided the neighboring teeth were healthy and in occlusion. Exclusion criteria were age under 18 and extraction sockets that had healed for less than 2 months.

The narrow implants were placed according to a one-stage procedure after flap elevation and a drilling sequence according to the manual. Sutures were removed after 1–2 weeks and the healing abutments were changed to individually modified TiDesign™ abutments at 6–10 weeks after surgery. Metal-ceramic crowns were thereafter permanently cemented. Probing pocket depth (PPD), bleeding on probing (BoP) and gingival zenith (i.e. distance from mid incisal edge to buccal gingiva) as well as intra oral radiographs were evaluated and compared at implant placement, crown cementation, as well as after 6 and 12 months of function. Annual follow-ups are scheduled further until 60 months.

Marginal bone level changes were determined by an independent radiologist, measuring mesial and distal distances from a reference point to the nearest bone crest in visual contact to the implant, and an implant mean value was calculated. Student's t-test was used for revealing differences between groups at the significance level of 5%.

Results: Sixty-nine patients received 1 or 2 narrow implants. In total, 97 implants of lengths between 11 and 15 mm were placed. The reason for tooth loss is illustrated in Figure 1. No complications occurred during surgery, however 4 implants were lost during the early healing phase, giving a total implant survival rate of 95.5%. The reason for failure was lack of stability in three cases, and infection in one case. Two patients experienced abutment fractures and 2 crowns had to be recemented.

PPD, BoP and gingival zenith did not change significantly over time. Pockets were on average 1.96 mm deep at permanent crown placement and 1.82 mm at the 1 year follow-up visit. Bleeding occurred at frequencies between 33% at start and 34% at the 1 year follow-up visit. Mid-facilal level of gingival margin, the so called gingival zenith, scored between 8.95 mm to 8.66 from baseline to the final 1-year follow-up visit.

The marginal bone level changed slightly from implant placement to loading by -0.44 mm. An average gain in marginal bone level was noted between loading and 6 months. The total marginal bone level change from implant placement to 1 year was -0.06 mm (SD 1.02).

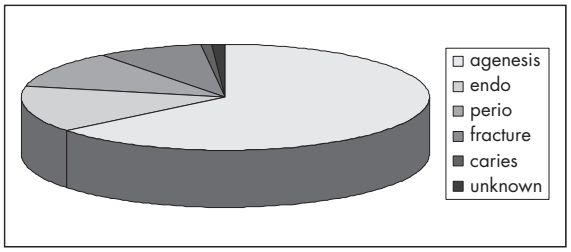

Figure 1. Pie diagram illustrating the reason for tooth loss: tooth agenesis 64%, endodontic failure 14%, periodontal reason 11%, root fracture 8%, caries 1% and unknown reason 1%.

Discussion and Conclusions: The 1-year clinical outcome shows that OsseoSpeed™ TX 3.0 S is a safe and predictable treatment option where physical space is limited in the anterior regions. Well maintained marginal bone levels, from day of surgery was recorded and healthy clinical conditions were reported.

Clinical evidence
II. Function

Clinical evidence is also about implant stability, bone adaptation at implants in extraction sockets, and the outcome when using immediate loading protocols. The patient's assessment of their quality of life is another important aspect to consider when evaluating the treatment outcome.

Related reading:

Immediate loading, fixed full bridges 36–37
Immediate loading, single tooth 28, 40
Early loading 11, 45
Patient's assessments 39, 41

The influence of insertion torque on the survival of immediately placed and restored single-tooth implants

Norton MR

Int J Oral Maxillofac Implants 2011;26(6):1333-43

Purpose: This retrospective study set out to investigate how single-tooth implants are influenced by a low peak insertion torque protocol (< 25 Ncm) with respect to implant survival and bone remodeling when placed in fresh extraction sockets and subjected to immediate loading.

Materials and Methods: There were 61 patients included in the study, all consecutively treated with 68 implants for immediate replacement of one or more failing teeth in the anterior area of the mandible or maxilla. Tooth extraction was carried out through the help of a periotome and careful tooth elevation, making sure to keep the labial cortical plate intact during the process. Prior to implant placement all extraction sockets were subjected to thorough curettage removing any remnants of dead, damaged or infected tissue, followed by a decontamination protocol with chlorhexidine gluconate. Most cases were treated with a minimal flap elevation or flapless surgery, only in cases of an apical fenestration a mucoperiosteal flap was elevated. Site preparation was performed in a way to ensure an implant placement where the top of the implant was located at or near to 1.0 mm apical to the labial crestal bone leaving approximately 3.0 mm to the labial free gingival margin and with a 1 mm gap to the buccal bone plate.

Self-tapping implants (ASTRA TECH Implant System™) were used and and placed with a maximum insertion torque of 25 Ncm. Only if there was a lack of axial stability of the implant, detected though manual tapping, the implant was excluded from the study. In case of existing extraction socket defects, bone augmentation was performed with autogenous bone and/or Bio-Oss. The implants were all connected to ST abutment or Direct Abutments immediately after implant placement onto which a plastic, prefabricated coping was connected. Provisional acrylic, resin crowns without centric or excursive contact points were thereafter provided.

Implant stability and health of peri-implant tissues was monitored on re-call visits 6 and 12 weeks following implant treatment. Permanent metal-ceramic or all-ceramic crowns were cemented between 3 and 5 months following surgery. Radiographic examination took place prior to cementation of the definite crown (radiographic baseline) and yearly there after. For peri-implant bone remodeling analysis only the most recent radiograph was used to record bone level changes from time of definite crown.

To detect correlation between bone loss and peak insertion torque Wilcoxon rank sum test was used. In addition correlation of bone loss with age, gender, position of the tooth, implant length or diameter was also performed.

Results: During the course of the study 3 implants out of the 68 was lost, all within 1 month following implant surgery, rendering an overall survival rate of 95.5% after a mean follow-up of 46 months. Mean overall insertion torque measured 22.5 Ncm, range 10–25 Ncm. Two of the failed implants had an insertion torque of 25 Ncm and one had a recorded torque of 15 Ncm. Bone grafting was applied in 54% of the implant sites.

Fifty-four implants (79%) had follow-ups longer that 2 years and these implants demonstrated a mean marginal bone loss of 0.23 mm (SD±0.60) on the mesial and 0.20 mm (SD±0.72) on the distal side of the implant. No correlation between amount of bone loss and insertion torque, age, gender, tooth position or implant length could be demonstrated.

Two cases reported signs of postoperative infections, which could be resolved with antibiotics. One patients complained about dull ache, and one patient presented soft tissue recession. All patients were pleased concerning the esthetics of their treatment.

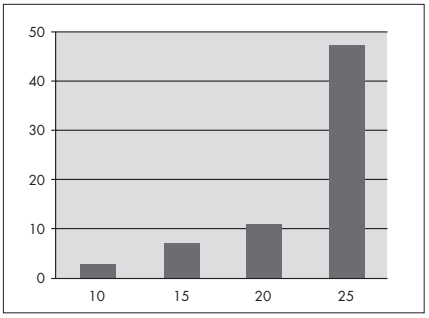

Figure 1. Frequency distribution showing number of implants placed (y-axis) with defined insertion torque (x-axis, Ncm).

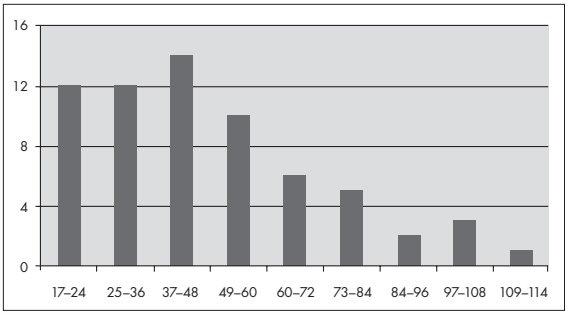

Figure 2. Frequency distribution showing the number of patients (y-axis) and how long they were followed up (x-axis, months) in this study. The follow-up period ranged from 16 to 114 months, with a mean follow-up time of 46 months.

Discussion and Conclusion: In the current study it was shown that even when applying a low insertion torque protocol for immediately loaded single-tooth implants placed in extraction sockets good survival rates and stable marginal bone levels could be achieved.

A 24-week prospective study comparing the stability of titanium dioxide grit-blasted dental implants with and without fluoride treatment

Geckili O, Bilhan H, Bilgin T
Int J Oral Maxillofac Implants 2009;24(4):684-88

The application of moderately rough surfaces along with other macro- and micro-topographical changes to implants surfaces and design have resulted in an enhanced rate of osseointegration to improve the early stability of the implant. Recently so-called nanotechnology has been applied to implant surfaces to further enhance this early stability and to speed up the rate of bone formation to yield an interface with higher shear strength. The use of a fluoride modified titanium grit-blasted surface (OsseoSpeed™) has shown promise in in vitro and animal experimental studies in this regard but little clinical data exists to support this contention.

Purpose: To compare fluoride-modified (FM) and unmodified (UM) titanium grit-blasted implants with regard to early stability as measured by resonance frequency analysis (RFA) in a clinical prospective cohort over a 24-week period.

Materials and Methods: Twenty-seven systemically healthy edentulous patients seeking mandibular overdenture therapy were enrolled to the study. Patients received 2 dental implants in the mandibular canine positions (ASTRA TECH Implant System™), one FM (OsseoSpeed™) and one UM (TiOblast™) placed on the left and right sides respectively and always the same dimension 4.5x13 mm. Surgery was performed according to manufacturer's protocol under antibiotic prophylaxis. All implants benefitted from transmucosal healing by connection of a healing abutment at the time of implant placement and tissues were sutured around each abutment. No denture was worn for one month after which a relined conventional denture was provided. Two weeks later dentures were connected to their respective implants via ball or Locator abutments.

Resonance frequency analysis (RFA) were performed at time of implant placement and then at weekly intervals from 1 to 6 weeks and at 12 and 24 weeks post-op using a calibrated magnetic peg device (Smartpeg Type 7, Integration Diagnostics) and the Ostell Mentor RFA analyzer (Integration Diagnostics) to record Implant Stability Quotient (ISQ) values. Results were subject to statistical analysis by analysis of variance and paired sample t-test to evaluate the presence of any differences between the implant surfaces

Results: All implants osseointegrated. There were no statistically significant differences in ISQ values at baseline for the two groups with means of 75.7 + 9.6 (UM) and 75.5 + 8.9 (FM). There were no significant changes in ISQ for FM implants while there was a significant decrease in ISQ values for UM implants to week 2 (70.8 + 16.9) with a subsequent rebound in values at week 3 (79.6 + 5.4). There were no significant differences between the groups at each time interval throughout the study period.

Discussion and Conclusion: RFA has been shown to provide insight into the stability of an implant such that very low ISQ values can be interpreted as evidence for an implant to be at risk of failure. Furthermore such vulnerable implants have been shown to demonstrate remarkable recovery in ISQ values when protected from functional loading or conditioned with progressive loading protocols.

At time of placement stability is derived purely from a mechanical relationship and values of 75 ISQ are typical and this study corroborates these findings. Thereafter early decreases in ISQ have been reported which coincide with the early remodeling that takes place at the bone-to-implant interface. This relationship was certainly reflected in the UM implant group in this study which demonstrated a significant decrease in ISQ values for the two weeks following implant placement. However no such decrease was noted for the FM implant group whose ISQ values during that period were notably if not significantly higher than for the UM implants.

It is possible that in other regions of the mouth where the over-riding density of bone is lower that differences may be more noticeable, there is also a need for greater sample sizes with randomization of implant position which was lacking in the current study.

Nonetheless it can be concluded from the current study that the application of fluoride modification may further enhance osseointegration and lead to greater stability for the implant during the vulnerable early healing period.

A prospective, randomized-controlled clinical trial to evaluate bone preservation using implants with different geometry placed into extraction sockets in the maxilla

Sanz M, Cecchinato D, Ferrus J, Pjetursson EB, Lang NP, Lindhe J
Clin Oral Implants Res 2010;21(1):13-21

Immediate placement of dental implants into extraction sockets has been demonstrated clinically and histologically to be as predictable as implant placement in healed sites. The immediate placement of dental implants in extraction sockets is associated with residual bone defects between the walls of the extraction socket and the neck of the implant at the time of placement. Depending on the size of this defect, various studies have recommended the use of regenerative materials or barrier membranes to fill or cover these gaps thus preventing epithelial or connective tissue cell ingress, favoring bone regeneration. While some studies can demonstrate that immediate placement in an extraction socket may prevent or decrease the hard tissue loss which predictably follows tooth loss, others have shown that as new bone is formed around the implant, corresponding bone loss from the buccal and lingual aspects of the ridge can be demonstrated.

Purpose: The aim of this prospective, randomized, controlled multi centre study was to determine the association between the size of the void established using two different implant configurations and the amount of buccal/palatal bone loss occurring during healing following implant installation into extraction sockets.

Material and Methods: Ninety-three patients (≥18 years) requiring the extraction of a maxillary tooth in the 15 to 25 region fulfilled strict inclusion criteria for this study. Following the atraumatic extraction of the tooth using a periotome, patients were randomly allocated to group A or B. Group A utilized uniformly cylindrical implants whereas group B utilized implants which were cylindrical in the apical aspect but tapered cervically. All implants (OsseoSpeed™) were placed with healing abutments according to the manufacturer's protocol. In order to evaluate the bone at time of placement and to describe the size of any defects between the socket walls and the implant surface, the following landmarks were defined: Implant surface (IS), Implant Rim (IR), Top of bone crest (BC), Inner border of bone crest 1 mm from BC (IBC), Outer border of bone crest 1 mm from BC (OBC) and base of the defect (DB). After placement, the following measurements were taken, by independent examiners, on the buccal and palatal aspects of each implant, to the nearest millimeter using a standard periodontal probe: IS-IBC (Horizontal defect), IS-OBC (Horizontal distance from implant to outer crest of ridge), IR-DB (Vertical Defect), IR-BC (vertical distance from implant rim to bone crest). The buccal and palatal bone wall thickness was measured with calipers. A strict postoperative regime followed, with review after 1 week. Implants were allowed to heal for 16 weeks prior to re-entry to repeat the previous measurements prior to restoration.

The results were subjected to statistical analysis at the 95% confidence interval to test the null hypothesis that the reduction in the buccal bone plate thickness is constant, irrespective of the size of the void established by using different implant geometries,

Results: The mean reductions in IS-OBC, and IR-DB were not significantly different between the two groups on either the buccal or palatal aspects. Similarly, whilst there was no difference between the groups in reduction of IR-BC, the reduction was seen to be more pronounced at the buccal aspect. The measurement IS-IBC showed a significantly greater amount of reduction in group A than in group B on both the buccal and palatal aspects, $p < 0.05$.

Discussion and Conclusions: This study reinforces and corroborates the findings of numerous previous studies which have demonstrated that following tooth removal, the bucco-lingual ridge dimension decreases and buccal vertical crest reductions are seen to occur as a result of tooth loss. This marked decrease can be seen to occur regardless of immediate implant placement, the geometry of the implant, or a flapless surgery protocol. Whilst the ridge reductions measured in this study were fairly substantial, it must be considered that additional changes may in fact occur during the later phases of remodeling. This, together with the marked decrease in the vertical crest especially on the buccal aspect, reinforces the importance of proper planning prior to implant placement and positioning, especially in the esthetic zone to ensure that ridge alterations do not compromise the esthetic outcome of the case.

Management of peri-implant soft tissues between tooth and adjacent immediate implant placed into fresh extraction single socket: a one-year prospective study on two different types of implant-abutment connection design

Lops D, Mosca D, Muller A, Rossi A, Rozza R, Romeo E
Minerva Stomatol 2011;60(9):403-15

Purpose: The factors affecting the soft tissue response around an immediately placed implant are still not fully understood. A prospective, 6-months study was designed in order to evaluate the effect of the vertical and horizontal interplay on the size of the papilla, after immediate placement of implants in fresh extraction sockets. Two different implant abutment connection designs, with or without platform shift, was evaluated.

Materials and methods: Any patient having a single tooth implant which had supported a crown for at least half a year, was eligible for inclusion. Further inclusion criteria were good oral and systemic health, preconditions for good compliance, treatment planned to receive another single tooth, and a thick gingival biotype (according to Kan et al. 2003). Conditions that must not exist were smoking >10 cigarettes/day, previous bone grafting or radiotherapy in the area, blood disease, uncontrolled diabetes, clenching/bruxism or a thin gingival biotype in the area.

Gentle removal of the failing tooth was performed after flap elevation. The implants were placed according to a 1-stage surgical protocol. The straight implants (25 Straumann StandardPlus®) were carefully placed with the implant shoulder located 1 mm apical to the cement-enamel junction of the neighboring tooth. The 25 platform shifted implants (ASTRA TECH Implant System™) were placed so that the top of the parallel implant wall was in level with the buccal bone wall. Healing abutments were connected to the implants, flaps were sutured, and temporary constructions were provided (removable or Maryland provisionals). Permanent gold alloy or zirconium crowns were cemented to individually selected permanent abutments of different materials (21 gold-platinum, 16 titanium, and 13 zirconium) after 3 months of healing.

Periapical radiographs were obtained on which the horizontal distance between the implant and neighboring tooth surface was measured (tooth distance=T-D, measured at the "ideal" level for marginal bone contact). A vertical variable was also measured on the radiographs, which was the distance from the crowns contact point to the coronal marginal bone of the adjacent tooth (crown distance=C-D). The size of the papilla was judged visually at a straight angle from the buccal surface, according to; good if the papilla filled up more than half of the interdental space, or small if the size of the papilla was half or less of the interdental space. Gingival index (GI) scored as 0 or 1, was also recorded.

Statistical relationship between variables measured was evaluated using χ^2–test at a significance level of P=0.05.

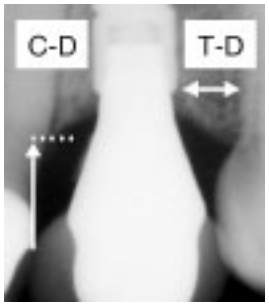

Figure 1. T-D, measured at nearest 0.5 mm at the level of the implant shoulder. C-D, measured to the nearest millimeter from the contact point to the level of coronal marginal bone of the neighboring tooth. Mesial and distal values were evaluated.

Results: All implants survived and no prosthetic complications were noted after 6 months in function. A significant relation between a T-D of 2.5 – 4 mm and a "good" papilla was found for both implant systems (i.e. provided the T-D=2.5 -4 mm, the papilla was scored "good" in 92.8% of the ASTRA TECH Implant System cases and in 78.6% in the Straumann cases).

When C-D was between 3–5 mm a significant correlation to a "good" papilla was observed for the platform shifted system (the papilla was scored "good" in 92.3% of the cases), but no significant relationship was observed for the Straumann system (where a "good" papilla was found in 66.6% of the cases). The ASTRA TECH Implant System and Straumann system had similar frequencies of papilla that were scored "good". Gingival index was for both systems 0 in 97%.

Conclusion and discussion: From this prospective, 6-month study, it was concluded that a horizontal tooth-implant distance (TD) of 2.5 – 4 mm is significantly associated with a present and adequate papilla, irrespective of platform shift design or not.

Three-year evaluation of single-tooth implants restored 3 weeks after 1-stage surgery

Cooper LF, Ellner S, Moriarty J, Felton DA, Paquette D, Molina A, Chaffee N, Asplund P, Smith R, Hostner C
Int J Oral Maxillofac Implants 2007;22(5):791-800

Purpose: The aim of this 3-year prospective cohort study was to evaluate the outcome of early loading of implants placed in healed maxillary anterior alveolar ridges. Primary variables were implant success rate and prosthesis complications, and secondary variable was to determine the conditions of the peri-implant tissue.

Materials and methods: Patients who signed informed consent were included at either of the two centres involved. The recruitment and treatment of the patients were in accordance with Committees for Investigations involving human subjects and the Declaration of Helsinki. Patient inclusion and exclusion criteria has previously been presented in detail (Cooper et al. 2001).

In total, 54 TiOblast™ implants were placed in a 1-stage procedure. Healing abutments were connected with light finger pressure. After 3 weeks a definitive abutment was selected, having the restorative margin about 1 mm below the mucosal margin. A temporary crown was cemented and checked for occlusal contacts in maximal intercuspidal position, with limited or no excentric contacts. The placement of the temporary crown was considered the baseline in this study. Eight weeks after implant placement, definitive crown impressions were made and permanent crowns were cemented with glass ionomer cement.

Radiographic and clinical follow-up programme started and was performed at 6 months, 1 and 3 years. Plaque and distance from incisal edge to top of the papilla, and to buccal gingival zenith was measured, as well as the width of the keratinized mucosa. A single independent investigator recorded peri-implant radiolucencies and marginal bone levels in relation to a reference point on the implant.

Descriptive statistics were calculated with a 95% confidence interval. The P value was calculated by Wilcoxon signed rank test.

Results: Forty-eight patients were treated with 54 implants placed in the maxillary canine, central or lateral incisor region. Three implants in 3 patients were lost before definitive crown cementation, giving a cumulative implant survival of 94.4%. Thirty-nine patients with 43 implants attended the 3-year follow-up. No abutment screw loosening or fracture occurred, and prosthetic complications included minor incisal porcelain fracture of 3 crowns, loosening of 2 temporary cemented crowns and 2 episodes of soft tissue character. Clinical evaluation showed low levels of plaque accumulation and only 4% of all sites showed peri-implant mucosal redness, at the 3 year control. The parameters evaluating changes in soft tissue health all showed improved results over time. Papilla size positively changed from permanent crown placement through out the study (0.53 mm at 6 m to 0.74 mm at 3 years) and the result was not an effect of the distance between the adjacent tooth and the implant (P>0.50, Kruskal-Wallis test). The distance from the incisal edge to the gingival zenith was reduced, indicating a growth of soft tissue at 1 and 3 years (0.34 ±0.94 mm and 0.51±1.42 mm, respectively). The marginal bone levels indicated initial changes from baseline to placement of the definitive crown (0.47 ±0.44 mm, P< 0.001) but no further statistically significant changes were recorded during the 1 and 3-year examinations (mean change from baseline to 3 year =0.42±0.59 mm).

Discussion: This study showed that early loading of TiOblast™ implants with MicroThread™ is associated with similar level of implant survival (94.4%) compared to single tooth implants of the same type conventionally loaded.

With regards to soft tissue healing and early loading protocols, this study clearly showed on a rapid and predictable reproduction of the peri-implant mucosa. No tissue recession was observed, as previously reported in the literature. The favourable results were attributed to the minimal bone level change, early delivery of well performed provisional restorations and to the stability of the connection of the abutment to the implant (absence of abutment screw loosening).

Minimal and limited marginal bone remodelling was found and there were no abutment related complications. The early loading protocol did not influence the preservation of the marginal bone which is in accordance with previously reported results. Again, the results are an effect of the design features of the ASTRA TECH Implant System™, having minute threads on the implant neck, an inner conical connection of the abutment to the implant, and a moderately rough implant surface.

A case-control study assessing oral-health-related quality of life after immediately loaded single implants in healed alveolar ridges or extraction sockets

Raes F, Cooper LF, Tarrida LG, Vandromme H, De Bruyn H

Clin Oral Implants Res; E-pub April 19, 2011, doi: 10.1111/j.1600-0501.2011.02178.x

Purpose: The purpose of this study was to evaluate the oral-health-related quality of life in patients in need of a single implant treatment in the maxillary esthetic zone. Immediate implant placement in fresh extraction socket or the conventional placement in a healed ridge was compared and analysed using a patient's questionnaire method Oral Health Impact Profile (OHIP).

Materials and methods: A multi centre case control study was undertaken. Patient informed consent form had to be signed and requirements such as a missing single tooth in the second premolar to second premolar region in the upper jaw, stable occlusal contact with a minimum of 20 teeth, and being ≥18 years old needed to be fulfilled. Patients were not allowed to enter the study if they had active caries lesions, a lack of neighbouring and opposing natural teeth, were smokers, had uncontrolled diabetes, were pregnant, had an alcoholic or drug abuse or any other local or systemic disease that would negatively affect healing and osseointegration. OsseoSpeed™ implants were placed either in healed ridges (50 patients) or fresh extraction sockets (46 patients) and immediately restored with a provisional crown cemented to Direct Abutment. Eight weeks later a permanent ceramic crown was fabricated and cemented on a titanium abutment.

Quality of life, evaluated by the OHIP questionnaire was judged by the patient when left alone in the room; before treatment started, after provisionalization, after permanent cementation of final crown, and more than 6 respectively 12 months after permanent crown cementation. The questionnaire was divided into 14 questions (7 domains) and the patient answered the questions after a Lickert-like scale from 1–5 where 1 is the maximal negative result i.e. problems very often and 5 corresponds to never any problems. Changes in the patients response over time and between groups was evaluated.

Results: Any incomplete patient questionnaire at any time point disqualified the patient for being included in the statistical analysis (12 patients). Two patients had implants that failed (one in each group) and these patients were not included in the statistical analysis. In total 82 patients were reviewed. Cumulative implant survival rate was 98% after 12 months in function.

Overall OHIP score (i.e. average from functional limitation, physical disability, physical pain, psychological disability, psychological discomfort, social disability and handicap) revealed no difference between the groups at any time point. Significantly less discomfort was noted at the first 6 month of treatment (compared to baseline), where after no change in total OHIP was found. In depth analysis revealed that the decreased discomfort found, was significantly more pronounced in the healed alveolar group (i.e. they had recorded a greater improvement in functional limitation, physical disability, physical pain, psychological discomfort) than in the extraction sockets group (i.e. had not recorded significant improvement in psychological disability, social disability and handicap).

Discussion and conclusion: Patients included in the study had, at start a failing tooth or a provisional restoration covering a missing tooth. The treatment modality granted a provisional or definitive crown at all time making the actual change not that apparent. Still, it was possible to show an increase in patient related quality of life lasting until the end of the observation period, i.e. 12 month after implant rehabilitation. The positive change was more pronounced in the healed ridge group which could possibly be explained by the patients improved self-confidence turning a provisional restoration to a permanent restoration.

Clinical evidence III. Long-term results

ASTRA TECH Implant System™ is an implant system designed and proven clinically to maintain marginal bone. The clinical success is due to three reasons: the biomechanical and clinical principles of the ASTRA TECH Implant System BioManagement Complex™, the excellent work of the dental professionals, and the continuous oral care by the patients.

In this section we present outstanding long-term results and small variations in bone resorption pattern between study reports. As a consequence of the well-preserved marginal bone, excellent esthetics are maintained as well.

Long-term clinical evidence

Related reading:

Effect of surface topography of screw-shaped titanium implants in humans on clinical and radiographic parameters: a 12-year prospective study

Vroom MG, Sipos P, de Lange GL, Grundemann LJ, Timmerman MF, Loos BG, van der Velden U
Clin Oral Implants Res 2009;20(11):1231-39

The application of moderately rough surfaces was introduced on the basis that it would help to promote stronger interfacial shear strength (osseointegration) as measured by resistance to removal torque, a higher percentage of bone-to-implant contact and thus lower maximum bone stresses. It is postulated that this would ultimately result in better maintenance of marginal bone levels. In addition it was proposed that in contrast to very rough surfaces such as titanium plasma spray, these moderately rough surfaces would not give rise to significantly more peri-implant infections than a normal machined surface.

Purpose: The current study was set up as a double blind randomized prospective clinical and radiographic study to compare the marginal bone response and status of the peri-implant soft tissue for moderately rough and machined surface implants of identical geometry, placed into the same patients and monitored for up to 12 years.

Material and Methods: Twenty edentulous patients with a mean age of 53 years were enrolled to the study. Alcohol and drug abuse, uncontrolled diabetes, local pathology of the jaws and bruxing were exclusion criteria. Smokers were included. All patients received 4 implants from ASTRA TECH Implant System™, 2 TiOblast™ and 2 machined implants which were placed into the anterior mandibular jaw, mesial to the mental foramen using randomized assignment of surface for the first implant at the left premolar site followed by placement of alternate surfaces thereafter. Implants were submerged and subsequently exposed approximately 4 months after placement and definitively restored by means of a bar and overdenture construction.

All patients were subject to both clinical and radiographic follow-up at baseline, 6-months post prosthesis insertion and then annually for 5 years thereafter. A further follow-up was undertaken after 12 years. Clinical parameters included plaque index (Silness & Löe 1964), presence or absence of calculus, bleeding on probing (van der Weijden 1994), pocket depth, and the analysis of the location of the gingival margin. Measurements was performed at four sites around each implant by the same examiner, who was blinded as to the surface type of the implant. All measurements were repeated at 10% of sites to assess intra-examiner variability.

Intra-oral long-cone radiographs were taken using a standardized technique with individualized film holders for the left and right sides of each patient to ensure reproducibility of radiographs. Devices were secured directly to the individual abutments to rule out any variability in positioning. Images were digitized and linear measurements taken from the implant/abutment junction to the most coronal bone-to-implant contact to the nearest 0.01 mm. Measurements were compared from the 6-month, 1-, 5- and 12-year reviews. Again intra-examiner reproducibility was assessed.

Results: Only 2 machined implants failed to osseointegrate and these were replaced and the replacement included in the follow-up analysis. All implants remained in function at the 12-year review. 7 patients were lost to follow-up. Most of the clinical parameters remained stable from baseline to the 12-year review with mean plaque scores ranging from 0.19 to 0.39, little or no evidence of calculus, bleeding scores ranging from 0.2 to 0.55, gingival zenith ranging from 1.63 mm to 2.4 mm and pocket depth ranging from 2.25 to 2.82 mm. There was no evidence of any influence by surface type on these clinical parameters. For turned implants the mean marginal bone loss measured -0.04 mm at baseline and decreased (i.e. bone gain) to +0.01 mm (±SD 0.5) at the 12-year review. Similarly for TiOblast implants, baseline bone loss measured – 0.08 mm compared to +0.01 mm (±SD 0.58) at the 12-year review. There were no significant differences between surface type within any time frame or across the entire study period.

Discussion and Conclusions: The current study was established to provide robust evidence of the influences exerted by surface topography on the hard and soft peri-implant tissues, via a randomized, double blinded clinical trial in which patients received both surface types, thus removing the patient as a confounding variable. Furthermore the use of screw-retained customized film holders significantly reduced the influence error when comparing images for linear measurements. It can therefore be concluded that for this data set from edentulous patients there is no difference in soft or hard tissue changes around machined or TiOblast implants, and that the latter are no more susceptible to peri-implant infections than the machine implants.

A split-mouth comparative study up to 16 years of two screw-shaped titanium implant systems

Jacobs R, Pittayapat P, van Steenberghe D, De Mars G, Gijbels F, Van Der Donck A, Li L, Liang X, Van Assche N, Quirynen M, Naert I

J Clin Periodontol 2010;37(12):119-1127

Purpose: The aim of the study was to compare the long-term outcome of 2 different implant systems having either a machined or a rough implant surface utilizing a randomized split-mouth design. The primary variables were changes in marginal bone levels and bone densities over time.

Material and Methods: Patients with bilateral posterior edentulism seeking for treatment at either the Department of Periodontology or the Department of Prosthetic Dentistry (University Hospitals, UZ KU Leuven, Leuven, Belgium) were screened for inclusion. Inclusion and exclusion criteria are presented in the 2-year follow-up report [1], and follows general criteria for implant treatment including patient's signed informed consent and having Kennedy Class-1 in the upper or lower jaw. In total 18 patients were included.

The ASTRA TECH Implant System™ with the TiOblast™ surface, a smooth neck design, a diameter of 4.0 mm, and varying lengths, was used on one edentulous side. On the other side, each patient received the Nobel Biocare Brånemark System implants™ which had a machined surface, a diameter of 3.75 mm, and varying lengths. The implants were left submerged for 5 months before abutment surgery took place and final delivery of screw-retained fixed partial ceramo-metal dentures was performed.

Following prosthetic delivery, i.e. baseline, clinical and radiological assessments took place at annual recalls. Sulcus bleeding index (Mühlemann & Son, 1971), presence of plaque (yes/no), probing pocket depth were recorded as well as marginal bone levels as measured from intra-oral radiographs. The mesial and distal bone levels were measured from the reference level to the first bone-to-implant contact using Adobe Photoshop software. Bone densities were evaluated at the mesial and distal sides by using Densito® Software. The periotest value (Siemens AG, Bensheim Germany) was recorded at the 1 and 10-year follow up. A prosthetic evaluation was also conducted including the recording of complications, porcelain chipping retightening of abutment or bridge screws etc.

Statistical analysis was performed using Statistica Windows software with a p-level set to 0.01. The analyses were performed on patient and implant level and a linear regression analysis was performed in order to reveal changes over time for marginal bone levels and pocket depths. Differences between the two systems were analyzed by Wilcoxon matched pair test.

Results: There were no differences between the implant systems in regards to any parameter evaluated at any time point. The cumulative implant survival rate was 97.7% for the Brånemark System and 100% for the ASTRA TECH Implant System, after 16 years in function. A 100% bridge survival was noted. Porcelain chipping and screw retightening occurred at 3% and 8%, respectively. The patients oral hygiene was good during the entire follow-up period in most patients. The periotest value decreased from 1 year to 10 year whereas radiographic bone density increased during the same period. The mean marginal bone loss did not differ significantly from baseline values or between the systems at any time point, Figure 1. It was however noted that the bone level at ASTRA TECH Implant System was located closer to the implant abutment junction, at a distance of 0.4 ± 0.59 mm, while the corresponding figure was 1.79 ± 1.06 mm for the Brånemark implants. When measuring the bone loss at neighboring teeth (distal side) it was found that on average 0.5 ± 0.7 mm bone was lost during the 16 year period.

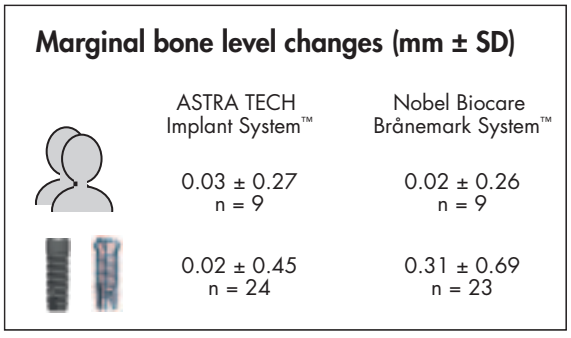

Figure 1. Marginal bone level change from baseline to 16-years follow-up. Patient level results on the upper row and implant level results on the lower row.

Discussion and Conclusion: Clinical and radiographic parameters remained stable during the entire 16 year follow-up period and were not different between the systems. Surface topography had thus no effect on hard and soft tissue variables in this randomized split-mouth clinical trial. These results are similar to what has been reported previously in other long-term clinical studies on ASTRA TECH Implant System.

References:

1. van Steenberghe D. et al*. A prospective split-mouth comparative study of two screw-shaped self-tapping pure titanium implant systems. Clin Oral Implants Res 2000;11:202-209.*

Longitudinal changes in tooth/single-implant relationship and bone topography: an 8-year retrospective analysis

Chang M, Wennström JL

Clin Impl Dent Rel Res; E-pub Feb 10, 2010, doi: 10.1111/j.1708-8208.2010.00272.x

It has been established that the bone peak at the surface of a natural tooth is the dominant factor for determining the fullness of the interproximal papilla between a tooth and an adjacent implant. Furthermore the changes over time in the vertical discrepancy between tooth and implant due to alveolar growth and vertical tooth drift or indeed due to marginal bone loss at the surface of the implant, results in loss of bone height at the surface of the tooth and eventually a loss of papilla height, compromising esthetics.

Purpose: This study was established to determine any longitudinal changes in the bone topography adjacent to single-tooth implants (ASTRA TECH Implant System™).

Materials and Methods: Only 4.5 mm diameter tapered implants (TiOblast™, MicroThread™) placed in the upper jaw between 15 and 25 and in function for at least 5 years were included in the study. Baseline radiographs were required from time of crown cementation and then at 5 years follow-up. If 8-year radiographs were available these were also included. All implants were placed using a submerged protocol and allowed to heal for 6 months prior to abutment connection using the ST-Abutment system. At exposure all implants were temporized and definitive crowns inserted one month later. Standardized radiographs were taken using individually fabricated film holders to ensure the film was perpendicular to the x-ray beam. Linear measurements were recorded on digitized images of each radiograph, using the implant diameter and micro-threaded conical collar length to calibrate each radiograph. The most coronal bone contact at the mesial and distal of each implant (CBC) was evaluated with respect to the base of the bevel at the shoulder of the implant, which was used as the reference, 0.3 mm below the microgap. In addition the level of the bone peak at the adjacent teeth was measured from the cement-enamel junction (TBP).

The tooth-implant vertical discrepancy (TIVD) was measured from the cement-enamel junction to the reference line and the horizontal gap (TIHG) was measure from implant surface to tooth surface at the level of the reference line. Apical position was measured in relation to the thread level on the implant.

Measurement error was evaluated using 10 randomly selected images which were re-assessed after a 2 week period. Differences for CBC, and TBP were only 0.01 mm while TIHG was 0.02 mm and TIVD was 0.04 mm. The differences equated to less than half a thread. Results are expressed as mean values, mm (+/- SD).

Results: A total of 33 implants were included in the study, 10 of which were in central incisor positions, 9 lateral incisors, and 11 first bicuspids and 3 second bicuspids. The mean change in CBC to 5 years was -0.1(1.1), and for TBP was 0.0 (0.4). 8-year values were -0.1 (1.3) and -0.1 (0.5) respectively. The mean TIVD was 4.1 mm and mean TIHG was 2.1 mm. When assessing the tooth apexl relation to the threads of the implants it was apparent that the vertical change at 5 years measured 0.37 mm for incisors and 0.19 mm for premolars. At 8 years these values were 0.53 mm and 0.15 mm respectively. Statistical analysis revealed no significant influence of any variable on the outcome data. Change in vertical position of adjacent teeth at 5 and 8 years was statistically significant, $p < 0.05$. This correlated to a greater presence of infra-occlusion in the incisor positions, $p = .025$.

Discussion and Conclusion: Consistent with previous studies the current implant demonstrates minimal changes in marginal bone levels, only -0.1 mm over 8 years. Indeed 48% of implants revealed no marginal bone loss, with only 13% demonstrating bone loss > 1.0 mm. Similarly bone loss at adjacent teeth over 8 years was also minimal and it could be confirmed that both vertical and horizontal relationships between tooth and implant exerted no influence over outcome. This finding bodes well for long-term esthetic stability for interdental papillae and gingival zenith for teeth adjacent to the ASTRA TECH Implant System. However ongoing tooth eruption may result in infra-occlusion and a discrepancy of gingival zenith for single-tooth implant restorations.

Fixed implant-retained rehabilitation of the edentulous maxilla: 11-year results of a prospective study

Mertens C, Steveling HG, Stucke K, Pretzl B, Meyer-Baumer A
Clin Impl Dent Rel Res; E-pub Jan 17, 2012, doi: 10.1111/j.1708-8208.2011.00434.x

Purpose: This long-term prospective study was undertaken to assess the clinical and radiological outcome of implant supported full bridges in the maxilla.

Materials and methods: The study was approved by the Ethics review board (Heidelberg University) in 1998 and patients were included during 1999.

Inclusion criteria were; age between 18 and 75 years, completely edentulous maxilla with enough bone to support 9 mm long implants in healed alveolar ridges, no medication or disease that could jeopardize osseointegration. Seventeen patients received each 6–8, parallel walled, moderately rough titanium implants with MicroThread™ at the coronal portion (TiOblast™, ASTRA TECH Implant System™). A single surgeon performed the operations (for details please see Mertens et al. 2010 [1]). Following 6 months of healing, UniAbutments were placed and definitive screw-retained prostheses were delivered. Oral care instructions was performed, baseline periapical radiographs was taken and re-examination visits were scheduled at 6 and 12 months and yearly thereafter. The level of the marginal bone was evaluated at 5, 8 and 11 years.

At yearly visits, plaque index and bleeding index were assessed and motivation and instructions for oral hygiene, including cleaning, were performed. At the final 11-year visit a more profound evaluation was undertaken. Patients were classified as non-smokers or former/current smokers. Probing pocket depth and bleeding on probing were assessed as was clinical implant stability tested (i.e. abutment torque resistance of 20 Ncm). Any presence of subgingival periodontal pathogens were assessed by microbiological testing (ParoCheck 20, Greiner Bio-One). After supra-gingival cleaning, sterile paper points were placed in the deepest pockets of each implant, pooled per patient and sent for laboratory analysis. Also patients expression of the inflammatory marker Interleukin-1 genotype was examined through collecting mucosal cells in a sponge swept over the soft tissue, and sent for laboratory analysis (Genotype IL-1, Hain Lifescience GmbH).

Evaluation of implant success was made according to criteria by Albrektsson et al. from 1986. The success criteria by Karoussis 2003, which defines status of the peri-implant tissues including evaluation of the pocket depth was also applied. Implant survival was defined as an implant being in function. Descriptive statistics was calculated. Multivariate analysis of risk factors for implant failure was not possible to perform due to the low number of patients and low number of implant failures.

Results: One patient died and another patient moved away geographically, hence 15 patients treated with 94 implants and followed for 11 years, could be reported on. The followed patients were on average 55 years at start of the study and the majority were females (66 %). Forty-four % responded they were current smokers and 27% of the patients showed an IL-1 positive genotype at the final visit. At yearly recalls, soft tissue health was generally acceptable with a mean plaque index of 0 or 1 in 85% of the sites and a bleeding index of 0 in 76% of the sites. One female, smoking patient with IL-1 positive genotype but without significant accumulation of periodontal pathogens, lost 3 implants (1 during healing and 2 after 9 years, the latter both due to peri-implantitis) and her bridge had to be remade. No other implant losses occurred, resulting in a total implant survival rate of 97% and a bridge survival rate of 93%. No serious technical complications occurred during the course of the study.

Mean marginal bone loss on implant level, increased from 0.25 mm at 5-years to 0.30 mm at 8 years and reached 0.56 mm at 11-years. There were two patients (7 implants) displaying marginal bone loss exceeding 3.2 mm, giving a success rate defined by Albrektson et al of 86.7% on a patient base, and 92.6% calculated on an implant base. Applying the stricter success criteria by Karoussis et al. resulted in a patient based success of 53.3% and implant level success of 83.0%. Furthermore, using Karoussis criteria on a patient basis, it was found that current smokers, IL-1 positive patients and men had lower success rates compared to non-smokers, IL-1 negative genotypes and women. The microbiological analysis failed to show relationship with biological complications. Actinomyces odontolyticus was associated with deeper pockets while Aggregatibacter actinomycetemcommitans was not detected in any patient.

Discussion and conclusion: Focusing on clinical and radiographic outcomes this long-term prospective study reported a 96.8% implant survival rate and a success rate of 92.6% of implants placed in the edentulous maxilla. These figures are comparable with previously reported long-term follow-up studies. Six to 8 moderately rough MicroThread implants supporting a fixed prosthesis is an efficient treatment option for patients edentulous in the maxilla.

References:

1. Mertens C, Steveling HG. *Implant-supported fixed prostheses in the edentulous maxilla: 8-year prospective results. Clin Oral Implants Res 2010;22(5):464-72.*

A 10-year prospective study of single tooth implants placed in the anterior maxilla

Gotfredsen K
Clin Impl Dent Rel Res 2009;14(1):80-7

In an effort to achieve a high degree of esthetics and function the single-tooth implant replacement (STIR) has been identified as the treatment of choice, especially when the adjacent teeth are un-restored. The 5- to 10-year survival has been shown to be comparable to that for fixed conventional bridgework, although there are few 10-year follow-up studies on STIR to date. The literature suggests that such studies might demonstrate a higher complication rate. In addition differing protocols for immediate, versus early and delayed placement might yield differing outcomes.

Purpose: The aim of this study was to presents 10-year data from a cohort of STIRs placed in both an early and delayed manner and reflect on both biological and mechanical outcome.

Material and Methods: Twenty healthy patients, mean age 33 years, required replacement of a single missing tooth in the anterior segment. Two groups each with 10 patients were assigned to early placement (Group EP) 4 weeks after extraction and delayed placement (Group DP) 12 weeks after extraction. No socket preservation procedures were undertaken. Implants (ASTRA TECH Implant System™ ST, Ø 4.5 mm) were placed with the shoulder bevel leveled with the lingual crest. Any residual buccal defects were protected by a non-resorbable membrane to aid guided bone regeneration. Submerged healing was allowed for 6 months prior to exposure and membrane removal. Implants in group EP were restored using prefabricated abutments while those in the DP group received prepable abutments. All implants were restored with cemented ceramometal crowns. Occlusion was refined to within 40 µm.

Baseline clinical and radiographic assessments were made within 2 weeks of crown cementation and annually thereafter. Examinations included an assessment of implant/crown immobility, presence/absence of pain, plaque scores, bleeding on probing to a depth of 2 mm, and the recording of any adverse biological or technical events. Radiographs were taken using a standardized paralleling technique with an Eggen film holder. The distances from the implant reference point at the base of the coronal bevel to the first point of bone-to-implant contact as determined at x7 magnification was recorded on the mesial and distal of each implant. Finally patient were asked to score the esthetics and function of the crown at the 3- and 10-year review on a 100 mm VAS scale where 0 = dissatisfied and 100 = very satisfied. Statistical analysis using paired and unpaired t-tests was undertaken to determine the influence of time and protocol respectively on the resultant marginal bone levels.

Results: While some patients were absent from the occasional annual review all patients were seen across the study and only one patient missed the final review although this patient was available for telephone interview to confirm that nothing had changed from the previous review. Thus it was possible to confirm a 100% survival rate for implants and a 90% survival rate for crowns, with 2 crowns having to be replaced during the study. With regard to adverse events, one patient presented with a mucositis at the 10-year review, two crowns required re-cementation, three crowns fractured one of which required replacement and two abutment screws came loose and required re-tightening, one of which resulted in the need for a new crown. Patients scored a mean of 9.4 for function at 3 years which reduced to 8.4 at 10 years and 9.3 at 3 years reducing to 7.6 at 10 years for esthetics.

At the 10-year review the mean marginal bone loss measured 0.64 mm in group EP and 0.86 mm in group DP, there was no significant difference over time or between the groups for any of the clinical or radiographic parameters assessed.

Discussion and Conclusions: Results of the current study corroborate the findings of previous systematic reviews with respect to both implant and crown survival. The maintenance of marginal bone in the current study was superior to that anticipated by established criteria, while technical complications with the crown appeared more consistent with previous studies. However the use of the more robust prepable abutment appeared to resolve the problems of decementation and abutment screw loosening. It can be concluded that the ASTRA TECH Implant System is well suited to single-tooth replacement and that patient scores for function and esthetics, while reducing over time, remain high even after 10 years.

A 5-year prospective study of Astra single tooth implants

Palmer RM, Palmer PJ, Smith BJ
Clin Oral Implants Res 2000;11(2):179-82

Purpose: To evaluate a single-tooth implant over a 5-year follow-up period.

Material and Methods: 15 patients each received one ASTRA TECH Implant System™ ST implant (Ø 4.5 mm). 11 implants were short, measuring 11 mm and four measured 15 mm in length. Implants were placed according to recommended surgical protocol with the head of the implant 2 to 3 mm apical to the cemento-enamel junctions of the adjacent teeth. In total 6 central incisors, 8 lateral incisors, and 1 bicuspid were replaced. No additional ridge expansion or grafting procedures were used for any implants.

All implants were left to osseointegrate for 6 months prior to connection of the 0.0 mm ST abutment in 12 cases and the 1.0 mm ST abutment in 3 cases. Implants were temporized either with the ST coping or a temporary crown. Ceramometal definitive crowns were placed as early as possible. Patients were followed-up every 6 months to determine clinical stability of the crown and tissue health.

Radiographs were taken using a long-cone technique at crown cementation and annually thereafter, and were assessed at x7 magnification. Marginal bone level was measured with reference to a defined point at the top of the implant. Results were subject to statistical analysis.

Results: One patient was lost to follow-up. For the remaining 14 patients all attended their review appointments.

No implants have been lost and there have been no soft tissue problems and minimal bleeding on probing. Prosthetically there have been no recorded cases of abutment screw loosening. One crown has decemented and required recementation after 18 months. One further crown suffered porcelain fracture and required replacement.

Mean distance for the marginal bone level measured from the reference point to the most coronal bone to implant contact point was at crown cementation (baseline) 0.46–0.48 mm. No statisticaly significant change occurred in bone levels to the 5-year follow-up (0.36–0.43 mm at 5 year). 33% of implants measured no bone loss and in some cases there was a clear bone gain.

Discussion and Conclusion: The single-tooth implant was most effective at replacing missing teeth.

The system was simple to use and there were very few complications. All implants remained in function and screw joints remained stable throughout the study. Excellent soft tissue health was maintained around all implants.

Marginal bone levels were extremely well maintained over the 5-year follow-up and may be attributable to the TiOblast™ surface and MicroThread™ design of the coronal portion of the implant.

A 10-year follow-up study of titanium dioxide-blasted implants

Rasmusson L, Roos J, Bystedt H
Clin Impl Dent Rel Res 2005;7(1):36-42

Purpose: This prospective study set out to evaluate the 10-year cumulative survival rate and marginal bone levels at 199 TiO_2-blasted implants.

Materials and Methods: Patients with either edentulous maxillae or mandibles were enrolled in the study on a consecutive basis. Patients with uncontrolled diabetes, alcoholism, irradiation or mental illness were excluded. Smokers (n = 4) were included. Of the 36 patients enrolled, 28 were available for their 10-year follow-up, with a total of 155 implants.

Implants (TiOblast™ 3.5, 4.0) were inserted according to manufacturer's recommendations and benefited from a submerged healing protocol of 3 to 6 months, at which time they were exposed for the connection of 20° UniAbutments.

Intra-oral radiographs were taken using a paralleling technique both at baseline (insertion of prosthesis) and annually thereafter. Radiographs were analyzed using image capture software. All bone levels were measured with respect to the implant reference point at the base of the most coronal bevel. All bone levels above this reference point were recorded as zero.

A life table was constructed which would compensate for the lost data and give a better reflection of the likely 10-year outcome for these implants.

Results: During the study observation periodonly 6 implants were lost, 3 of which were mandibular and 3 maxillary. All failures were early losses identified at abutment connection. The cumulative survival rate for all implants was 96.9% and for maxillary implants alone this figure was 96.6%.

There were few prosthetic complications and bridge screw fracture only occurred in one patient, and this was attributed to an ill-fitting framework. After a complete re-make no further screws broke in this or any other patient. Survival rate of the superstructures was 100% after 10 years.

Soft tissues were recorded as healthy with an absence of bleeding on probing in greater than 90% of all sites.

For the 100 first inserted implants, marginal bone loss data revealed a mean of 1.27 mm from the reference point at the 7-year follow-up.

Discussion and Conclusion: This study represents the first 10-year follow-up for implants with a micro-textured surface of the order of 1.10 µm.

The cumulative survival rate was impressive being 97.2% for mandibular implants and 96.6% for maxillary implants, which is better than rates recorded for machined implants. In addition it is noteworthy that all failures were early, and no late failures were recorded. It can be speculated that TiOblast implants therefore perform better in low-density bone. The annual bone loss rate equates to 0.15 mm/year suggesting marginal bone remains stable at these microroughened surfaces. Furthermore the incidence of soft tissue complications appears to remain very low, which is likely a function of the conical implant/abutment joint design.

Early and immediate loading of titanium implants with fluoride-modified surfaces: results of 5-year prospective study

Mertens C, Steveling HG
Clin Oral Implants Res 2011;22(12):1354-60

Aim: to prospectively evaluate if a fluoride modified dental implant surface has a positive clinical effect over a 5 year period.

Material and methods: Seventeen patients fulfilled the inclusion criteria (i.e. being ≥18 year, eligible for placement of 2–5 implants using a one-stage protocol) and signed the informed consent form. Eleven patients had a record of periodontal disease treated before the implant rehabilitation. Exclusion criteria were general exclusion for implant surgery, drug or alcoholic abuse, bone augmentation in the area or active periodontal disease. A total of 49 OsseoSpeed™ implants were placed in the maxilla (33) and mandible (16) using a one-stage surgical protocol with flap elevation. Seven implants were placed in extraction sockets whereof 4 became immediately loaded. The surgery took place at the Dep. of Oral and Maxillofacial Surgery (University of Heidelberg). In total, 14 implants were immediately loaded (Direct Abutment™ and provisionalization), while 35 implants were early loaded (Healing Abutment Zebra). Impression was carried out at 6 weeks, and final restoration delivered at 8 weeks in most situations. Prosthetics consisted primarily of single crowns (31), but also partial (4) and fixed full bridges (1). Implant survival, complications, oral health parameters and Jemt's papilla index were assessed at final prosthetic connection, at 6 months and at yearly follow-up visits. Radiographic analysis of the marginal bone levels took place at prosthetic connection and at the annuall recalls. Radiographic success was assessed according to Albrektssons criteria (1986). The mesial and distal first visible bone-to-implant contact was recorded on radiographs calibrated for distortion, by an independent radiologist. At the 5-year follow up, patients also filled in a questionnaire about their subjective response to the implant-supported rehabilitation.

Results: The patients received 2 to 5 implants each. The treatment indications and patient population represented the general implant patient pool at the clinic. Fifteen patients with 42 implants were able to attend the 5 year follow-up. One patient died and one patient moved geographically away. Mean marginal bone loss after 5 years of loading, irrespectively of loading protocol, was 0.1 mm (SD 0.4). Immediately loaded implants showed similar good long-term bone preservation as the early loaded implants (0.18 mm vs. 0.00 mm, p 0.265).

Implant survival was 97% (1 implant failed before loading). Radiographic success was, however, 100% (according to Albrektsson et al 1986). Clinical complications were restricted to 1 implant which showed signs of peri-implantitis. Papillae were present (score 2 or 3) in situations with neighboring teeth. No technical complications were recorded during the study period. All patients were "very satisfied" with regards to their prosthesis at the 5-year visit.

OsseoSpeed™	Final prosthetic connection	5 years follw-up
Plaque Index	26%	6.1%
Signs of inflammation	16%	4.2%
Papilla score 0 or 1	31%	25%
Papilla score 2 or 3	69%	75%

Discussion and Conclusions: This study was undertaken to evaluate the clinical effect of a fluoride-modified implant surface over long-time follow-up. Patients with varying indications, periodontal status and bone quality was included. It was concluded that fluoride-modified implants as studied here, show high survival and high success rate over a 5 year follow-up period.

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- **Natural Shape™** – shape and emergence profile based on individual patient anatomy
- **Soft-tissue Adapt™** – optimal support for soft tissue sculpturing and adaptation to the finished crown.
- **Custom Connect™** – strong and stable fit – customized connection for all major implant systems.

ATLANTIS™

ATLANTIS™ abutments are patient-specific abutments available for all major implant systems. The abutments are individually designed from the final tooth shape using a unique and patented software, ATLANTIS VAD™, enabling the production of milled titanium, gold-shaded titanium (TiN) and zirconia abutments.

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Facilitate is a computer guided diagnostic planning tool for efficient, accurate and predictable implant treatment based on a 3D visualization of the patient's anatomy, including vital structures, implants, abutments and teeth. Facilitate is based on the successful SimPlant™ software from the Dentsply family member Materialise Dental™.

Marginal integrity of direct and indirect castings for implant abutments

Ganz SD, Desai N, Weiner S
Int J Oral Maxillofac Implants 2006;21(4):593-9

Purpose: The purpose of this study was to measure and compare the marginal gap size (accuracy) of metal copings fabricated on direct i.e. computer-milled abutments (CMA), or with indirect technique i.e. on epoxy and stone dies. This in order to evaluate if the ATLANTIS™ technique has clinical advantages such as reducing the steps (positive-to-negative transformations) in implant laboratory restorative procedures.

Materials and methods: Ten computer-milled abutments were used in the experiment. They were milled from a block of commercially pure titanium into a standardized premolar shape (mesial-distal width of 7 mm, bucco-lingual width of 8 mm, 10º occlusal convergence, 11 mm high and the apical 3 mm serving as the collar). 5 ATLANTIS abutments were placed on each side on implant analogs positioned in a jaw model only having the incisors left for orientation.

After impression with vinyl polysiloxane material two full arch working casts were produced.

The casts which had removable dies, were made of epoxy resin and type IV die stone. Marginals were exposed after careful trimming. Casts in type III alloy were then made for all three modeling techniques, a) directly on the titanium computer-milled abutments coated with 2 layers of die spacer prior to wax up and casting; b) indirect wax ups on the epoxy resin dies coated with 3 layers of die spacer; c) indirect wax ups on the stone dies coated with 2 layers of spacer and casting. The castings were cleaned and fitted to respectively epoxy or stone dies, or if computer-milled fitted to the abutment prior to analysis. At imaging in the microscope (60X Olympus SZX12 equipped with a USB camera) a custom built holder was used fixating the abutment and castings (a finger pressure level) to ensure complete seating. The images were analyzed with a specialized imaging and measurement software program (Bioquant 2000, Biometrics) at five uniform sites along the marginal interface. A mean marginal gap value was calculated for each casting, and was compared using a 1-way analysis of variance and pairwise comparison (Scheffé test). Additionally, casts made from epoxy and stone dies were photographed and measured as controls.

Result: A comparison of the marginal gap of metal copings between indirectly made dies (on epoxy and stone) and those made directly on duplicate abutments was performed. Further, in order to reveal the quality of the CMA, the gap at copings seated on the abutment from which they were waxed were compared with the gap after transfer to a duplicate abutment. The castings made from direct technique had the smallest mean marginal gap ($P \leq 0.001$). The gap was not significantly changed when these casts were transferred to the duplicate abutment. The result for the direct technique was clinically acceptable. Using the indirect technique resulted in larger gap sizes irrespective of die material (epoxy or stone). The marginal gap of indirect castings were also larger on casts from epoxy dies compared to stone dies.

Discussion: The uncertainty of the impression steps and provisional abutment can be avoided with an even higher accuracy of the final cast when using the ATLANTIS technique. The result from this study show that computer-milled abutments can be duplicated with sufficient accuracy and allow an exchange of casting between the original abutment and the duplicate abutment. In the clinic this result in shortened treatment time, increased fit and reduced number of laboratory remakes.

A comparison of fabrication precision and mechanical reliability of 2 zirconia implant abutments

Kerstein RB, Radke J

Int J Oral Maxillofac Implants 2008;23(6):1029-36

Purpose: Published studies indicate that zirconia is a reliable implant abutment material. Zirconia possesses several positive characteristics such as biocompatibility, favourable color and mechanical properties, which makes the material suitable for use in modern dentistry. The purpose of the study was to compare fabrication precision and fracture strength of two types of commercially available zirconia abutments; the ATLANTIS™ Abutment Zirconia (DENTSPLY Implants*) and the Procera AllZirkon abutment (Nobel Biocare).

Material and Methods: Twenty-nine abutments of each type (ATLANTIS and Procera AllZirkon) were created by their respective manufacturers to fit a Brånemark System implant with external hex, diameter 4.0 mm (Nobel Biocare). Ten abutments of each type were randomly selected for precision measurements using a coordinate measuring machine with a small-diameter touch probe (Brown and Sharpe, North Kingston, USA). The following dimensions of the abutment interface area were recorded in order to evaluate fabrication precision: hex dimensions (mean of three measurements of opposite hex walls), bore diameter concentricity, mean counterbore diameter, and mean true position of the counterbore to bore.

The remaining specimens were used to measure fracture strength, and to analyze fracture origin and propagation characteristics. Each test specimen (connected implant and abutment) was loaded in a standardized testing machine (Instron Corporation) in an angled manner, simulating maximum implant-abutment misalignment and off-axis loading. Increasing loads were applied until fracture of the specimens. Maximum failure load was recorded and the probability of failure was evaluated for the two abutment types. Next, the characteristics (location and nature of fracture origin) of the fractures were analyzed.

Results: The calculations performed on the fabrication precision of the abutment interface determined that there were no statistically significant difference between the two abutment designs. The mean load to fracture values were 831±69 N for the ATLANTIS abutments and 740±96 N for the Procera AllZirkon abutments. This difference was statistically significant. Furthermore, the load to failure data demonstrated a higher probability of failure for the Procera AllZirkon abutment compared to the ATLANTIS abutment under intraoral occlusal loads.

Scanning electron microscopy analyses of the fractures showed that fracture origins for both types of abutments were typically small irregularities in the as-processed surface. However, the analyses revealed noticeable differences in the crack propagation between Procera AllZirkon and the ATLANTIS abutment, with the ATLANTIS abutments showing consistent fracture origin of the inner hex interface surface for all test abutments. The fractured surface appeared smooth and continuous throughout the fractured surface. The Procera AllZirkon, on the other hand, exhibited fracture origin at the radius inside the hex, and the fractured surface was visibly irregular.

Discussion and Conclusions: The authors conclude that both types of zirconia abutments showed failure loads exceeding maximum human bite force, however, mean load to failure was significantly higher for the ATLANTIS abutment compared to the Procera AllZirkon abutment. In addition, the ATLANTIS abutment showed a statistically significant higher probability to survive occlusal loads. There were no significant differences between the interface features measurements for the two abutments types. The difference in strength would therefore most probably not be related to the precision of the respective fabrication process, but rather a result of the raw stock material that each company uses in its abutment fabrication process.

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Implant adaptation of stock abutments versus CAD/CAM abutments: a radiographic and scanning electron microscopy study

Apicella D, Veltri M, Chieffi N, Polimeni A, Giovannetti A, Ferrari M
Annali di Stomatologia 2010;1(3-4):9-13

Background: A good precision of fit of the abutment to the implant is important in order to assure long-term successful treatment results. Misfit at the implant abutment interface could cause mechanical complications such as screw loosening or component fracture. Moreover, a gap at the implant abutment margin could lead to bacterial accumulation and potentially result in biological complications such as peri-implant inflammation. The aim of the study was to evaluate the difference in fit between stock abutments versus patient-specific CAD/CAM abutments in titanium, gold shaded titanium and zirconia, when placed on an implant with an internal conical connection (OsseoSpeed™).

Material and Methods: Six different groups of abutments were connected to 72 OsseoSpeed implants (sample size = 12 in each group). For the purpose of the study, the ATLANTIS and Aadva CAD/CAM abutments were designed to match the shape of the stock abutments.

Group	Type of abutment
1	Titanium stock abutments (TiDesign™, ASTRA TECH Implant System™)
2	Zirconia stock abutments (ZirDesign™, ASTRA TECH Implant System™)
3	CAD/CAM zirconia abutments (Aadva Zr abutment, GC, Tokyo, Japan)
4	CAD/CAM titanium abutments (ATLANTIS™ Titanium, DENTSPLY Implants*)
5	CAD/CAM gold shaded titanium abutments (ATLANTIS™ Gold Hue, DENTSPLY Implants*)
6	CAD/CAM zirconia abutments (ATLANTIS™ Zirconia, DENTSPLY Implants*)

Table 1. Type of abutments

Clinically, abutment seating is often evaluated using radiographs, and in order to simulate the clinical setting all implant abutment assemblies were subjected to radiographic analysis and the adaptation of the different abutments into the corresponding implant was assessed. The adaptation of each abutment was scored 0 (perfect adaptation), 1 (no complete adaptation) or 2 (clear evidence of no adaptation). The scoring was made by two evaluators and was double blind. Any disagreements was solved by re-evaluation of the specimens until an agreement was established.

All specimens were then embedded in acrylic resin and cut for scanning electron microscopy (SEM) evaluations of the precision of fit between the implant and abutment. The inner adaptation (i.e. presence of any marginal gap between the implant and the abutment) was measured digitally with a freeware image analysis software, and was scored 0 (gaps not exceeding 5 microns, perfect adaptation), 1 (gaps greater than 5 microns but not exceeding 20 microns, no complete adaptation), or 2 (gaps greater than 20 microns, clear evidence of no adaptation). The SEM images were evaluated blindly by two operators, and inter-operator disagreements were solved by re-evaluation. The Kruskal-Wallis test was used to reveal any statistical significant difference among the adaptation scores between the six groups. The level of significance was set to $p<0.05$.

Results: All the six different implant-abutment assemblies revealed good adaptation as shown by both radiographic and SEM evaluations. All abutment groups scored 0 with regards to radiographic adaptation (i.e. perfect adaptation). In addition, the SEM analysis showed mean internal gaps not exceeding 5 µm for any groups, resulting in score 0 for all six groups. No statistically significant differences were found between the groups. Moreover, radiographic scores were in agreement with the SEM scores, and no disagreement between the operators existed.

Discussion and Conclusions: In conclusion, the patient-specific CAD/CAM abutments ATLANTIS and Aadva, and the stock titanium and zirconia abutments showed comparable marginal fit to the OsseoSpeed implants. All samples showed good adaptation as evaluated both by conventional radiographs and by scanning electron microscopy, indicating that radiographic evaluation of the abutment adaptation in the clinical situation is a reliable method. However, further studies in humans are needed to confirm the results of the investigated CAD/CAM abutment systems in a clinical setting.

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Presentation of two cases of immediate restoration of implants in the esthetic region, using facilitate software and guides with stereolithographic model surgery prior to patient surgery

Kamposiora P, Papavasiliou G, Madianos P
J Prosthodont 2011;21(2):130-37

Purpose: Implant surfaces and surgical techniques are constantly developed, resulting in reduced healing times and more predictable results in terms of implant survival, all of which are beneficial to the patient. Surgical trauma and post-operative complications can be reduced through the use of flapless surgery and by placing the permanent abutments already at implant insertion thus avoiding disruption of the peri-implant soft tissue. The use of Facilitate™ software and stereolithographic models enable careful pre-planning of surgical implant placement and also planning and fabrication of provisional and permanent restorations. In the current clinical report this approach of pre-planning is described for two patients, both in need of immediate restorations.

Materials and Methods: The two patients were CT scanned, and by using the Facilitate™ software, 3D images of their jaws were created. Facilitate interactive software allows for virtual implant placement within the 3D image, generating information that can be utilized to create actual surgical guides and stereolithographically fabricated models. With the help from these tools, the planning for placement of permanent ceramic abutments and a provisional prosthesis at time of implant placement could be performed before the actual surgery.

Case presentation: *Patient A:* This patient needed replacement of a single central incisor, lost several years ago and currently replaced by a temporary orthodontic retainer-like construction. The orthodontic retainer in combination with poor oral hygiene had resulted in mucogingival inflammation. The patient was instructed in oral hygiene and the soft tissue was left to heal for 4 months after which CT scans were taken. Images (created by Facilitate) in the facial-lingual direction gave information regarding what implant length and inclination to be used and through panoramic image view, root positions of adjacent teeth were evaluated to secure they were not compromised. A surgical guide and stereolithographic model of the jaw was made based on the planned implant placement using the Facilitate software and used to perform the surgical steps including abutment connection and provisional prosthesis. The ceramic abutment was adjusted and modified in the model to be able to give proper support for a crown. There was initial problems with the accuracy of adjacent teeth of the CT scan. This could however be corrected by increasing the sensitivity of the digital images which the stereolithographic model was based upon. The surgical intervention followed the approach planned in the software by applying the surgical guides. A flapless surgery was applied when placing an OsseoSpeed™ implant. Connection of the abutment needed no further adjustments and the provisional crown was adjusted to prevent direct occlusal loading. Four months following surgery the implant was stable, showing optimal soft tissue health, and allowing for permanent all-ceramic crown fabrication and placement.

Patient B: This patient also needed a single implant restoration but for the lower second molar. The same procedure as described for patient A was followed where a stereolithographic model was used to simulate the surgical intervention with respect to implant placement, ceramic abutment connection and modification and fabrication of a provisional crown. During surgery great care was taken to reach appropriate insertion torque for the implant and to adjust the occlusion given the posterior placement of the implant. Radiographs taken directly after surgery confirmed good precision of implant placement from the pre-surgical planning. One week following surgery, soft tissue showed excellent healing. Permanent crown was placed following 2 months post-surgery.

Discussion and Conclusion: To achieve a successful implant treatment and avoiding a number of problematic events associated with implant esthetics it is suggested to use flapless surgery, place permanent abutment already at surgery and to use all-ceramic material for the restorations. This implant management scheme was implemented in two cases presented here showing promising results in terms of soft tissue reactions and implant stability. However, to achieve success, careful patient selection is required as well as technical precision. The patients described here are part of a larger trial evaluating the technique described and the long-term clinical outcome.

Effect of smoking habits on accuracy of implant placement using mucosally supported stereolithographic surgical guides

D'haese J, De Bruyn H

Clin Impl Dent Rel Res; E-pub May 20, 2011, doi: 10.1111/j.1708-8208.2011.00353.x

A number of studies have demonstrated a discrepancy between the implant positions planned using virtual planning softwares and those achieved *in vivo*. This has been shown to be due to a number of errors that can occur within the chain of data transfer from the virtual to the real world.

Purpose: This study set out to reveal any differences in accuracy between planned implant positions and *in vivo* placed implants, between smokers and non-smokers, when using the Facilitate™ software for planning and performance of guided surgery in the edentulous maxilla.

Materials and Methods: Thirteen patients requiring implants for the rehabilitation of their edentulous maxillae were enrolled in the study. Patients with a smoking habit were allowed, but other typically listed contra-indications were not allowed. At least 3 months after the extraction of hopeless teeth, impressions were taken of the edentulous jaws for diagnostic wax-up and subsequent fabrication of a full upper jaw denture. This prosthesis incorporated small radiopaque glass spheres so that it could also act as a scanning template. A dual scan procedure was undertaken and the patient and prosthesis was reconstructed in 3 dimensions using the Facilitate™ software (DENTSPLY Implants*). Prosthetically driven virtual planning of 6 OsseoSpeed™ implants and 4 fixation screws was idealized. The plan was sent to the manufacturer for fabrication of a stereolithographic surgical guide to incorporate metal sleeves for drill guidance and depth control. Implants were generally positioned 3 mm submucosally to allow for the establishment of the biologic width.

Six smoking patients received together 36 implants and 7 non-smokers received together 42 implants. At surgery, the mucosa supported guides were fixed to the bone through the mucosa, by fixation screws. Osteotomies were prepared according to the manufacturer and implants were inserted through the guide, without tissue punch through the mucosa, at a maximum torque of 50 Ncm. The guide was removed and standard Uni-Abutments™ (Astra Tech AB*) were connected and master impression taken for the production of screw-retained fixed prostheses which were delivered within 8 hours.

The thickness of the lingual and buccal mucosa was evaluated at 12 equally distributed reference points along the scanning template. The nearest distance from the alveolar ridge to the base of the scanning template was measured at 15 mm distance from the different reference points on the template on radicular sections of the scans.

Post operative CT scans were taken within 2 months and a specialized software (Mimics 9.0, Materialise) was used to merge the virtual plan image with that of the actual implants *in vivo*. An iterative closet point algorithm was used to align the two images. The mean coronal, apical and angular positions were evaluated and compared for deviation between the two sets of images

Statistical analysis was performed using SPSS software for non parametric analysis performed with the Kruskal-Wallis and Mann Whitney *U* tests. Differences were considered statistically significant if $p < 0.05$.

Results: One implant out of 78 placed failed to osseointegrate (1.3%). No complications were reported with the use of the surgical guides. When comparing the virtual plan images to the actual post-operative images of the implants *in vivo* there was a statistically significant deviation found for apical and coronal placement. Coronal deviation was 1.04 mm in smokers and 0.8 mm in non-smokers ($p<0.05$). Apical deviation was 1.26 mm and 1.02 mm in smokers and non smokers, respectively ($P<0.05$). The angular deviation was not significant different between planning and *in vivo* scans and was 2.64° and 2.57° in smokers and non-smokers, respectively.

The mean mucosal thickness in smokers (3.19 mm) and non-smokers (2.43 mm) was statistically significant different ($P<0.05$).

Discussion and Conclusions: Smoking patients have a thicker mucosa leading to larger inaccuracies when using mucosa supported stereolitographic guided surgery. The thicker mucosa lead to higher degrees of freedom when placing the scanning template or surgical guide onto the tissue. Hereof, clinicians need to be aware of the risk for global coronal and apical deviations which become accentuated for smoking patients when using a mucosa supported stereolitographic surgical guide technique.

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Checklist for critical reading of clinical documentation and scientific articles

Reading scientific articles and clinical documentation is essentially about being able to judge how reliable the results are and what they mean for you in your clinical work. In order for a scientific article to be deemed credible, certain data must be present. Here is a list of important and necessary information to look for:

☐ Purpose of the study

Why was the study performed? The purpose should be compared with the conclusion.

☐ Type of study

Is it a prospective or retrospective study? Generally, prospective studies are better, since the criteria are set before the patients are treated.

☐ Number of clinics involved

How many clinics are involved? More than one clinic should be involved in the study, in order to judge the possibility of repeated results.

☐ Number of patients

How many patients are included in the study?

☐ Inclusion and exclusion criteria

What are the criteria for a patient to be included in or excluded from the study?

☐ Number of implants for upper and lower jaws respectively

The number of implants should always be listed separately for upper and lower jaws, including failure statistics, as the treatment prognosis is different in each jaw. An additional advantage is if you can see the difference between anterior and posterior treatment.

☐ Follow-up

How many implants have been followed for how long? When did the follow-up start; at installation or at loading?

☐ Indications

Which indications are covered in the study; single, partial or full bridge? If it is a full bridge, is it fixed prosthesis or overdenture?

☐ Loading

When were the implants loaded (immediate, early or conventional loading)?

☐ Implants lost

A study should include both the number of implants and number of patients not accounted for during the entire follow-up period. It should also include the reasons for drop-outs.

☐ Success criteria

What is a successful result according to the authors? It is important that the success criteria are clearly described.

☐ Other important parameters

How were the results verified? Was x-ray used when determining bone levels? How were bone levels measured? Was the bridge removed to control implant stability?

☐ Statistical analysis of success and failure rates

A study should include statistical facts and figures to reveal how many implants were actually followed up and for how long. It should also include a "worst-case" analysis, meaning a calculated failure rate assuming that all drop-outs were lost implants.

☐ Complications

If there are complications or drop-outs, they should be clearly described.

☐ Conclusion

The conclusion should be compared with the purpose of the study. Was it fulfilled? What does the study actually tell you? How does the result affect your daily clinical work?

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