Clinical Performance of Short Dental Implants

CAD/CAM Customized Abutment for Soft Tissue
Ease of drilling sequence – Minimized drill sequence (2~4 drills) allows precision of osteotomy site preparation and less chair time for both dental surgeons and patients.

Color coding – Implant vials and drills are color coded to eliminate confusion.

Wide selections – Wide selection of implant sizes and prosthetic options are available to meet the needs of all dental surgeons.

Call now to learn more 888.446.9995
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Case Report: The Tripod Configuration for Implant Retained Overdentures Offers More Flexibility with GPS™ Abutments</td>
<td>Dr. Alessandro Onesti</td>
</tr>
<tr>
<td>12</td>
<td>An Invitation to Enter a New Field of Dental Implant Surface Modifications: A Review</td>
<td>Dr. Preeti Pachauri, Dr. Lakshmana Rao Bathala, Dr. Rajashek-Ar Sangur, Dr. Tanu Mahajan</td>
</tr>
<tr>
<td>21</td>
<td>The use of Milled CAD/CAM Customized Abutments to Control Soft Tissues in the Aesthetic Zone: A Case Study</td>
<td>Dr. Tim Doswell, Steve Campbell</td>
</tr>
<tr>
<td>29</td>
<td>Rehabilitation of the Anterior Maxilla with Guide Bone Regeneration and a Dental Implant Supported Prosthesis: A Case Report</td>
<td>Dr. Manesh Lahori, Dr. Lanka Mahesh, Dr. Rahul Nagrath, D. Dipta</td>
</tr>
<tr>
<td>37</td>
<td>Clinical and Radiological Performance of Short Dental Implants (6.5mm): 2 years Follow Up</td>
<td>Jean-Nicolas Hasson, Jacques Hassid, Dominique Aubazac, Paul Zeman</td>
</tr>
</tbody>
</table>
Using revolutionary online technology, JIACD provides its readers with an experience that is simply not available with traditional hard copy paper journals.

WWW.JIACD.COM
Case Report: The Tripod Configuration for Implant Retained Overdentures Offers More Flexibility with GPS™ Abutments

Dr Alessandro Onesti, DDS¹

Background: The patient presented with compromised residual elements of the lower arch and a poorly adapting removable partial denture. Extractions were performed and a temporary complete lower denture was placed and relined with soft material. 3 months later the patient was ready for implant treatment. Treatment goals included improvement of lower denture stability, with hygienic and easy to maintain intra-oral components.

Method/Treatment Plan: implant retained overdenture, supported by 3 implants, positioned in a tripod configuration, each of them provided with a single attachment. Advantages of this tripod configuration included elimination of the antero-posterior rolling movement compared to a conventional 2-attachment implant-retained overdenture, resulting in a better functional comfort as well as in a lower rate of wear of the retaining components. However this configuration can be challenging if using conventional ball attachments, in reason of their lack of compliance to eventual implant disparallelism (max 10 deg).

Results/Conclusion: The GPS implant attachments offer a better compliance to an eventual disparallelism: 20 deg for the internal males and up to 40 deg when using external males. This features make this kind of attachment very useful when managing more than 2 implants. In addition, single attachments are far easier to maintain intraorally and offers a much better accessibility to domiciliary oral-hygiene procedures compared to a bar mesostructure. This aspect is crucial when dealing with aged patients with limited ability to access and clean intra-oral components.

Key Words: Tripod Configuration, Overdenture, Retention, Implant-Supported Prosthesis, Anterior Guidance

1. Adent Cliniques Dentaires, Switzerland
CASE REPORT

The reason for the practice visit is the patient’s desire for a quick solution to his problem. In most cases, however, various process steps first need to be carried out beforehand and this was also the case here. Before the lower jaw could be supplied with a new, implant-supported prosthesis, the prerequisites for function and adaptation of the removable dental prosthesis in the lower jaw needed to be transferred to a stable state and oral hygiene needed to be improved. For this, teeth were extracted and the lower jaw was supplied with a temporary prosthesis that was underlaid with soft material for the transitional period. The preoperative panorama image (photo 1) shows the initial situation. A lateral cephalometric radiograph was helpful here in order to get a good picture of the bone dimension in the anterior jaw area (photo 2). Our treatment objective was to prevent the dreaded anterior/posterior rocking effect using an implant construction in order to improve comfort and to avoid bone atrophy. This ruled out a telescoping prosthesis supported by only two implants as a treatment concept. At the end of the planning phase, it was determined that the best possible option was a prosthesis supported by three implants in a tripod configuration. Here, each implant has its own retention element. The desired effect: function, comfort and the least possible wear and tear rate of the retention elements. Thus, ball head or Locator® systems are possible options. However, please be aware that this kind of tripod configuration is extremely challenging if a conventional ball head is to be used as a retention element. Ultimately, only implant axes/insertion divergences of 10° are permissible, which, however, is something that bony structures often do not readily allow.

Systems similar to Locator®, such as the GPSTM abutments from Implant Direct offer significantly more freedom and potential for success. In addition, the individually adaptable retention rate is highly praised by many patients because of the individually adjustable retention sheaths made from plastics of different hardness levels. Such characteristics make this retention mechanism valuable for treatments with more than two implants. In addition, other advantages of the GPSTM abutment include the simple cleaning of the retention components and the even simpler positionability – in particular for older and disabled patients. Three months later at the beginning of June this year, the implantation was able to be performed. We performed the treatment with three SwishPlusTM implants (Implant Direct). The selected size: 4.1 mm in diameter × 14.0 mm in length. The self-tapering SwishPlusTM implant is compatible with both the Standard and Standard Plus implantation systems from Straumann®. The SwishPlus™ implant represents a further development in certain key areas. For example, the SwishPlus™ has a neck section made with both a polished shoulder and a microrough shoulder each measuring 1 mm as well as microgrooves that minimize the pressure on the crestal bone. This microrough surface offers me the option of placing the implant either in a sub- or transgingival position. The insertion posts and the duo grip cover screw supplied with the product are compatible with all insertion instruments, ratchets and screwdrivers from Straumann®. The self-tapering thread has proven itself in my practice, since, together with the conically tapered apex of the implant, it offers the desired primary stability. The ideal implant position is marked before the minimally invasive flap is designed (photo 3).
In order to protect the bone from unnecessary destruction and overheating, the final drill is used at an extremely low speed (approximately 85 rpm) (photo 4). The first implant serves as the angle set value for the subsequent steps. Using the insertion posts for easier orientation has proven useful for achieving the desired implant parallelism (photo 5 and photo 6). Photo 7 shows the implants with locking screw and extender. For wound closure, the mucous membrane is positioned around the locking screw and extender. The transmucosal healing allows for a very good maturation of the peri-implant soft tissue (photo 8). The post-operative panorama image shows the positioning of the implant body (photo 9). After six weeks, the adjustment of the prosthesis was carried out (photo 10). The appropriate GPSTM abutment was selected from among four possible length options. The abutment housing could then be easily placed in the prosthesis (dental lab: E. Samson, Martigny, Switzerland). Photo 11 shows the placement of the GPSTM abutments and the excellent healing of the transmucosa. The very convincing, aesthetic integration becomes apparent in photo 12.

Thanks to the tripod configuration the anterior/posterior rocking effect, which is typical for a ball head retention system on two implants, is practically neutralized. Anterior guidance is made possible; there is no need for a bilateral balanced occlusion (photo 13).

**Disclosure**
The author reports no conflicts of interest with anything mentioned in this article.

**Correspondence**
Dr Alessandro Onesti, DDS
Adent Cliniques Dentaires
Martigny: Avenue de Fully 53
CH 1920 Martigny - Switzerland
Tél: +41(0)273993000 Fax: +41(0)273993005
Lausanne: R.te du Chatelard 54b
CH 1018 Lausanne - Switzerland
Phone: +41(0)216442000 Fax: +41(0)216442005
Mobile: +41(0)767088186
Figure 2: Lateral cephalometric radiograph to assess the bone dimension.

Figure 3: Marking the ideal implant position.

Figure 4: The drill is used at an extremely low speed.

Figure 5: Insertion posts simplify the orientation.
Figure 6: Insertion posts simplify the orientation (secondary view).

Figure 7: Implants with locking ring and extender.

Figure 8: Wound closure.
Figure 9: Post-operative panorama image.

Figure 10: Adjustment of the prosthesis.

Figure 11: The placement of the GPSTM abutments.
**Figure 12:** The aesthetically convincing final result.

**Figure 13:** Anterior guidance is made possible.
Background: Titanium dental implants have been used successfully for centuries but they have serious shortcomings related to their osseointegration and the fact that their mechanical properties do not match those of bone. Current trends in dental implant therapy include use of endosseous dental implant surfaces embellished with nanoscale topographies. The objective of this review article is to summarize the role of nanoscale surface modifications of titanium dental implants for the purpose of improving osseointegration, along with merits and demerits of surface modifications and various techniques that can impart nanoscale topographic features to dental implants.

Methods: An electronic search of English language peer-reviewed dental literature was performed for articles published between December, 1987 to January, 2012. Search was conducted in Medline, PubMed and Google scholar. The search was supplemented by handsearch in selected journals and by examination of bibliographies of the identified articles.

Conclusion: Modification of dental osseous implants at nanoscale level can alter biological responses that may improve osseointegration and dental implant procedures.

Significance: Accomplishment of cell specific function is better understood by means of Nanotechnology. The ultimate goal is to search materials that will bring specialized technology to the bedside and improve quality of life and current standard of care.

KEY WORDS: Dental implants, engineered surfaces, intelligent surfaces, sputtering, superhydrophillic, chemical vapor deposition, osseointegration

1. Postgraduate student, Department of Prosthodontics, Rama Dental College, Kanpur, India
2. Professor and Department Head, Department of Prosthodontics, Rama Dental College, Kanpur, India
3. Professor, Department of Prosthodontics, Rama Dental College, Kanpur, India
INTRODUCTION
Nanotechnology has been around since the ancient times. The inspiration for the field of nanotechnology was provided by American Physicist and Nobel Laureate Dr. Richard Phillips Feynmaan in 1959. The term “Nanotechnology” was first coined by Norio Taniguchi in 1974. Nanomaterials, with basic structural units, grains, particles, fibers or other constituent components smaller than 100nm in at least one dimension, have induced an enormous amount of attention for improving disease prevention, diagnosis and treatment.\(^1\)

DISCUSSION
Chemical composition and electrical charge on the dental implant surface which is important for protein adsorption and cell attachment are determined by bulk composition and surface treatment. Most endosseous dental implants are made from grade 4 commercially pure titanium (cpTi) as it is stronger than other grades. Titanium alloys are mainly composed of Ti6Al4V (grade 5 titanium alloy) with superior yield strength and fatigue properties than pure titanium. Chemical composition of dental implant influences hydrophilicity of the implant surface. Highly hydrophilic surfaces seem more advantageous than hydrophobic ones in view of their interactions with biological fluids, cells and tissues.\(^2\) The clinical success of oral implants is associated with early osseointegration which depends on geometry and surface topography. Two types of responses occur after implantation. The first type involves the formation of a fibrous soft tissue capsule around the titanium implant. The second type of bone response is related to direct bone–implant contact without an overriding connective tissue layer. This is known as osseointegration. Surface properties like surface composition, hydrophilicity and surface roughness determines the rate and quality of osseointegration in titanium implants.\(^3\) Cochran and colleagues\(^4\) did a histometric study in canine mandible and demonstrated that the surface roughness of titanium implants affects the rate of osseointegration and biomechanical fixation. Wennberg et al\(^5\) in their histomorphometric evaluation of screw shaped implants concluded that the amount of bone in contact to the implant surface is dependent on the surface roughness. Increase in surface roughness makes greater specific surface area that give rise to more available surface active sites for reactions by higher thermodynamic reaction potential.\(^6\) Depending on the scale features, surface roughness can be divided into three levels: a) Macro level topography, b) Micro level topography and c) Nano level topography. Macro and Micro level surface features demonstrated to be efficient in enhancing in vitro and in vivo\(^7\) biological events but now it is documented that material-host tissue interactions are principally governed by nanometric surface modifications. As an outcome macro and micron-scale features can only at best have an indirect influence on cellular activity and thereby has inherently limited activity and achievement. Therefore, there is a necessity for surface features that can give rise a direct and rapid outcome. Various strategies have been formulated and enforced to nan-
Nanotopography can determine the process of cell migration, proliferation and differentiation by modulating cell behavior. These surfaces hasten the wound healing process as related to protein adsorption and cell adhesion following implant placement thus enhancing the process of osseointegration. Nanotopography modifications are described as surface nanoroughness that means adding nano features to the implant surface. A nanostructure is an object of intermediate size between molecular and micrometre-sized structures and often defined between 1 and 100 nm. Dalby MJ and co-workers revealed that nanoscale topography also influences cell adhesion and osteoblastic differentiation. Oh SH et al illustrated that nanotechnology can interpolate the implant surface at an atomic level and may determine the chemical composition of these surfaces. Nanorough titanium can enhance osteoblast adhesion and differentiation when equated to their nano smooth control.

**METHODS OF IMPLANT SURFACE MODIFICATIONS**

Surface morphology appreciably affects osteogenic cell activities, its phenotypes and so the speed and quality of peri-implant osteogenesis. This will ultimately lead to the establishment and upholding of bone implant integration. Implant surface chemistry, morphology and structure can be altered by three ways: Mechanical methods, Chemical methods, Physical methods. Principal function of these techniques is to modify the bio-mechanical characteristics of the implant surfaces such as stimulation of bone formation to improve osseointegration, removal of surface contaminants and improvement of wear and corrosion resistance.

**Mechanical Methods**

The main objective of mechanical surface modification is to obtain specific surface topographies, roughness, removal of surface contamination and to modify the adhesion in subsequent bonding steps. Mechanical methods include: i) Machining; ii) Grinding; iii) Polishing; iv) Blasting. These methods results in rough or smooth surfaces which can increase the adhesion, proliferation and differentiation of cells. First of all, material is cut according to required size. Afterwards grinding is required for surface treatment to remove hard abrasive particles from the implant surface. The finest polishing grade can exercise to change the surface to an extremely smooth, mirror-like surface. Grinding and polishing procedures are mainly used to convert the surface to a preferred surface topography. Therefore grinding and polishing methods for implant surface treatment are contemplated as an intermediate step prior to chemical treatment.

*Blasting* is a method that leads to the manufacturing of a porous surface accomplished through the collision with microscopic scales. The thickness of the porous layer is regulated by the granulometry of the particles. Grit blasting technique is practiced by bombarding surface with hard particles at high velocity for cleaning gross surface contamination, finishing and ameliorating the surface roughness. Alumina is one of the commonly used materials for blasting but use of alumina could compromise osseo-integration like particles detachment during the healing process and progressive absorption by the surrounding tissues. TiO2 is another alternative as a blasting material showing interest-
ing results in experimental studies. Ivanoff CJ & his colleagues\textsuperscript{12} evaluated histomorphometrically, demonstrated that TiO\textsubscript{2} blasted implants were associated to a significantly higher bone implant contact when compared with machined surfaces. The blasted particles are used to change the surface chemical composition and to remove the particulate contaminations. Although simple and partially appropriate, these alterations are too coarse to directly influence events on the spatial scale at which cells function. It is increasingly accepted that interactions between biomaterials and host tissues are regulated by nanoscale features. In addition adsorbed proteins and their aggregates are a few nanometers in dimension.

**Chemical Methods**

Chemical modification is one of the most common and pliable method to modify metallic surfaces on the nanoscale. It is based on chemical reactions occurring at the interface between titanium and its surrounding solution. Chemical method\textsubscript{w} include: i) Anodic oxidation; ii) Acid Treatment; iii) Alkali Treatment; iv) hydrogen peroxide treatment; v) sol-gel treatment; vi) Chemical vapor deposition.\textsuperscript{13} According to Bagno A and Di Bello C\textsuperscript{14} surface roughness, composition and enhancement of surface wettability are altered by chemical surface modification of titanium.

Anodic oxidation has been successfully used to alter smooth Ti implant surfaces into nanotubular structures with diameters less than 100 nm.\textsuperscript{15} By adjusting factors such as the chemistry of the electrolyte, voltage and current density one can accurately transform physicochemical properties of surfaces, diameter and the spacing between nanotubes. On Ti surfaces, anodization also permits to create pillar-like nanostructures with tunable sizes as well as to deposit a range of 10 mm-long titania nanotubes through a porous alumina mask. Nanostructured layers on various metallic surfaces have been similarly made using electrophoretic deposition. For example nanocrystalline hydroxyapatite (nano-HA) coatings (crystals size in the 15–25 nm range) and multi-walled carbon nanotubes have been laid down on titanium-based metals resulting in an enhanced bioactivity.\textsuperscript{16}

Acid treatment operates to remove the surface oxide and contamination which leads to a clean and homogenous implant surface. The acids commonly used are hydrochloric acid, sulfuric acid, hydrofluoric acid and nitric acid. It results in uniform roughness with micro pits ranging from 0.5- 2 μm, increase in surface area and enhances bone to implant contact. Takeuchi M et al\textsuperscript{17} evaluated the decontamination efficiency of three acids Na\textsubscript{2}S\textsubscript{2}O\textsubscript{8}, H\textsubscript{2}SO\textsubscript{4} and HCl to Ti surfaces as pretreatment of surface modifications and proposed that HCl treatment was as an excellent decontamination method. A combination of strong acids (or bases) and oxidants has been shown to efficiently creates networks of nanopits (pit diameter ranging from 20 to 100 nm) on Ti, Ti\textsubscript{6}Al\textsubscript{4}V, CrCoMo alloys and Ta.\textsuperscript{18} Surface topography can be meticulously controlled by adjusting the length of exposure, temperature and composition of the etching solutions. Variation in the nature of the etching solution makes possible to incorporate selected elements e.g. fluorine, which has antibacterial effects and contributes to bone formation.

Alkali treatment involves immersion of the titanium implants in either sodium or potassium hydroxide followed by heat treatment by rinsing in distilled water. This results in the development of a bioactive, nanostructured sodium
titanate layer on the implant surface. The surface acts as a site for the subsequent in vitro nucleation of calcium phosphates when dipped in simulated body fluid (SBF). This includes an initial formation of Ti-OH by release of sodium ions from the sodium titanate layer by the route of ion exchange. This is followed by development of calcium titanate as a result of reaction with the calcium ions from the fluid. Being negatively charged, Ti-OH groups react precisely with the positively charged calcium ions in the SBF to form calcium titanate. Phosphate and calcium ions get incorporated into this calcium titanate and get change into apatite which can facilitate favorable conditions for bone marrow cell differentiation.

Hydrogen peroxide treatment results in chemical dissolution and oxidation of the titanium implant surface. When titanium surfaces react with hydrogen peroxide, Ti-peroxy gels are produced. The thickness of titania layer formed can be controlled by calibrating the treatment time. Tavares MG & his coworkers demonstrated that thicker layers of titania gel are more advantageous for the deposition of apatite when immersed in simulated body fluid (SBF). A combination of NaOH and hydrothermal treatments has also been practiced to Ti to generate an extensive variety of bioactive nanostructures such as nanoleaves, nanoneedles, nanorods, nanotubes and multiscale octahedral whiskers.

The sol-gel process used to lay down TiO₂, CaP, TiO₂-CaP composite and silica-based coatings on the titanium implant surface. It includes controlled hydrolysis and condensation of a soluble pioneer to form a sol, a homogeneous suspension of submicroscopic solid oxide particles in liquid. Adhesion of TiO₂ sol-gel coatings on titanium substrate are perceived as a function of sintering temperature, chemical pretreatment and surface roughness. Bajgai MP & his associates studied bioactivity of titanium coating and observed that apatite growing faster in titania containing gel while substrate is dipped in SBF for 1 to 15 days. Nishimura and colleagues demonstrated a directed approach to assemble CaPO₄ nanofeatures on dual acid-etched cp Titanium implant surfaces. The deposition of discrete 20–40 nm nanoparticles on an acid-etched titanium surface led to increased mechanical interlocking with bone and the early healing of bone at the implant surface in a rat model. Gutwein and Webster equated the relationship of particle size and cell viability and proliferation compared to micron-particles and evaluated that nanoparticles of titania and alumina had less negative impact in cell viability and proliferation. There may be an improvement by nanoscale modification of surfaces using sol–gel coating methods. The quantum interaction of high electron density at the atomic level can enforce high bond strength between the substrate and nanoscale coating.

Chemical vapor deposition involves chemical reactions between chemicals in the gas phase and the surface of the substrate which leads to the deposition of a non-volatile compound on the substrate. Popescu S & coworkers did comparative study and concluded that the properties of metallic surfaces can also be altered at the nanometric level by chemical vapor deposition (CVD).

**Physical Methods**

The physical methods of surface modification includes: i) *Plasma spraying*; ii) *Sputtering*; iii) *Ion deposition*.

The plasma deposition method is able to generate an engineered-surface nanostructure with
features usually less than 100 nm. First of all a vacuum is used to eliminate all contaminants then kinetic energy guides the charged metallic ions or plasma to the implant surface. The process permits a wide range of materials (e.g. Ag, Au, Ti etc.) to be coated onto an extensive range of underlying materials (e.g. metals, polymers and ceramics). In dental implants, titanium particles deposit on the implant surface with a uniform pattern. This process is most commonly used for deposition of calcium phosphate coatings such as HA onto implant materials to improve their bioactivity. It increases the osteoblast density on the implant surface. According to De Groot K and colleagues, HA-coated implants have higher percentage of bone-implant contact. Regardless of clinical success plasma-spraying method has several disadvantages including reduced long-term adherence of the coating to the substrate material, uneven thickness of the deposited layer, variations in crystallinity and composition of the coating that can affect the stability of the implants as well as pose a health hazard.

Sputtering is a method in which atoms or molecules of a material are ejected in a vacuum chamber by bombardment of high-energy ions. This process is useful for the deposition of bioceramic thin films (based on Ca–P systems) due to the ability of the technique to provide greater control on the coating’s properties and improved adhesion between the substrate and the coating. Properties like biocompatibility, biological activity and mechanical properties such as wear resistance and corrosion resistance are improved by sputtering. Vercaigne S & his associates did histological evaluation using TiO$_2$ grit blasted and sputtered CaP implants, the sputtered CaP coatings showed improved initial fixation and healing response when implanted into the trabecular bone of the goat. The main drawback of this technique is that the deposition rate is very low and the process itself is very slow. The deposition rate is modified by using a magnetically enhanced variant of diode sputtering known as radio frequency magnetron sputtering. Radio frequency sputtering (RF) is used to deposit thin films of standardized CaP coatings on titanium implants. The benefit of this technique is that the coating shows strong adhesion to the titanium, the Ca:P ratio and crystallinity of the deposited coating can be changed easily. Magnetron sputtering is a viable thin-film technique as it allows the mechanical properties of titanium to be preserved while maintaining the bioactivity of the coated HA. Coatings were deposited in a custom-built sputter deposition chamber at room temperature. This method shows strong HA titanium bonding associated with outward diffusion of titanium into the HA layer forming TiO$_2$ at the interface.

The Ion Deposition method includes atomic rearrangements. This technique allows the fine control of the concentration and depth distribution of the implanted elements. The potential creation of superficial stresses and modification of preexisting surface nanometric features must be carefully considered when using this highly energetic process. Approach based on this technology offer the possibility to insert selected biologically effective ions (i.e. Ca$^{2+}$, F$^-$, Na$^+$).

**LATEST ADVANCES TO MODIFY DENTAL IMPLANT SURFACES**

The effect of laser procedure, pico to nanometer thin TiO$_2$ coatings and synergistic effect of micro-nano hybrid topography on titanium surface with UltraViolet (UV) Photo functionalization are recent
advances that will enhance the surface chemistry of titanium implant without altering their biologically proven surface morphology/topography.

**Laser modified nano-structured dental implant surface**

Laser is used as a micromachining tool to produce a 3-D structure at micrometer and nanometer level. This technique generates short pulses of light of single wavelength providing energy focused on one spot. It is rapid, extremely clean and suitable for the selective modification of surfaces and allows the generation of complex microstructures/features with high resolution. Its advantages are associated with precise, targeted and guided surface roughening. These advantages make the technique interesting for geometrically complex dental implant. Thomson & Esposito performed retrospective case series and developed laser micromachining process to create micro and nano structured surface roughness in only the inner part of the thread. The inner part of the thread is considered to be more suitable for bone formation than the outer part.

**Picometer to Nanometer thin TiO$_2$ coatings**

A TiO$_2$ coating of a thickness ranging from 300 pm to 6.3 nm was effectively applied using a slow-rate sputter deposition of molten TiO$_2$ nanoparticles to augment the surface oxygen components without changing the existing microscale architecture and roughness of the substrates. These biological effects were exponentially correlated with the thickness of TiO$_2$ and oxygen percentage on the surface suggesting that even a TiO$_2$ coating as thin as a picometer is effective in enhancing the biological capability of titanium. Sugita Y et al directed the possibility of pico to nanometer-thin TiO$_2$ coatings on micro roughened titanium surfaces and suggested that establishment of a super-thin TiO$_2$ coating ranging from pico-to-nanometer thickness accelerating the biological properties of the proven micro roughened titanium surfaces.

**Synergistic Effect of Nanotopography with Ultra violet (UV) photofunctionalization**

The effect of micro-nano hybrid topography on titanium surface with UV photofunctionalization is synergistic. UV Photofunctionalization is intended to be a new approach of surface enhancement as compared to conventional surface modification methods It cleans the implant surfaces by removing the contaminants of hydrocarbon via TiO$_2$-mediated photocatalysis and direct decomposition by ultra violet. Tsukimura N & his co-workers addressed the synergistic effects of UV photofunctionalization and identified regulatory surface factors determining these synergistic effects, the micropits with 300-nm nodules showing the highest bioactivity after UV treatment.

**CONCLUSION**

Nanoscale surface modification techniques are likely to promote reflective changes in the ways dental implants are designed and manufactured. Therefore any procedure that can enhance the performance of dental implants will have a major impact on the quality of life and result in major economic benefits to society. Progression in metallurgical, surface-engineering techniques and "intelligent surfaces" assure a new generation of improved dental implant devices with exclusive bioactive surfaces.
Correspondence:  
Dr. Preeti Pachauri  
Room no. 5,  
Staff accommodation,  
Rama dental college, Kanpur.  
Telephone No:  
+919838573886  
E-mail:  
pachauri.preeti@gmail.com

Disclosure  
The authors report no conflicts of interest with anything mentioned in this article.

References  
2. Zhao G, Schwartz Z, Wieland M, Rupp F, Geis-  
4. Cochran DL, Schenck RK, Lussi A, Higginboth-  
5. Wennerberg A, Hallgren C, Johansson C,  
7. Celietti R, Marinho VC, Trani T, Orsini G, Bracc-  
9. Dally MJ, Andar A, Nag A, Alfordson S, Tare R, McFarlane S, Orefeo RO. Genomic expression of mesenchymal stem cells to altered nanoscale topo- 
17. Takeuchi, M.; Abe, Y.; Yoshida, Y.; Nakayama, Y.; Ozaki, M. & Akagawa, Y. Acid pretreat-  
19. Tatares MG, De Oliveira PT, Nanci A, Haw- 
techopen.com/books/implant-dentistry-a-rapidly-evolving-practice/implant-surfaces-phys- 
31. Hanawa T, Kamiura Y, Yamamoto S, Kohgo T, Amemiya A, Uki H, Murakami K, Asaoka K. Early bone formation around calcium-ion-implant- 
34. Sugita Y, Ishizaki K, Iwasa F, Ueno T, Minami- 
35. Miyautchi T, Yamada M, Yamamoto A, Iwasa F, Suzawa T, Kamiyo R, et al. The enhanced charac- 

The Journal of Implant & Advanced Clinical Dentistry  • 19
ATTENTION PROSPECTIVE AUTHORS

JIACD wants to publish your article!

For complete details regarding publication in JIACD, please refer to our author guidelines at the following link:


or email us at:

editors@jicad.com
The restoration of implants in the aesthetic zone remains one of the great challenges in restorative dentistry. The central incisor is a particular challenge, with mismatches in symmetry usually being very obvious to the patient and observer. The symmetry of a central incisor is not only defined by the colour characteristics and shape of the restoration, but also by the soft tissue architecture of the peri-implant tissues. In addition to this, the loss of the interdental papillae may also compromise the final aesthetic result.

One of the traditional methods for controlling the soft tissues in the aesthetic zone is to fit a provisional crown to a modified pre-formed abutment, and adjust the emergence profile of this crown until a satisfactory soft tissue level has been achieved. By default though, this means that the provisional crown, and the permanent successor, may have a deeper cement margin. There is increasing evidence that this may increase the risk of peri-implant diseases such as peri-implant mucositis and peri-implantitis because of the risk of incomplete removal of the cement during fitting of the restoration which may go undetected.

This article discusses the merits of using milled CAD/CAM customised abutments in the aesthetic zone and a technique to control the healing of the soft tissues around them so that the use of a modified preformed abutment fitted with provisional crowns to control the soft tissues may be avoided.

**KEY WORDS:** Dental implants, prosthetics, CAD/CAM, abutments, temporization

1. Private practice, Practice in Knaresborough in North Yorkshire
2. Managing Director of Ambridge Ceramics Ltd
INTRODUCTION
The restoration of implants in the aesthetic zone remains one of the great challenges in restorative dentistry. The central incisor is a particular challenge, with mismatches in symmetry usually being very obvious to the patient and observer.

The symmetry of a central incisor is not only defined by the colour characteristics and shape of the restoration, but also by the soft tissue architecture of the peri-implant tissues. In addition to this, the loss of the interdental papillae may also compromise the final aesthetic result.

One of the traditional methods for controlling the soft tissues in the aesthetic zone is to fit a provisional crown to a modified pre-formed abutment, and adjust the emergence profile of this crown until a satisfactory soft tissue level has been achieved. By default though, this means that the provisional crown, and the permanent successor, may have a deeper cement margin. There is increasing evidence that this may increase the risk of peri-implant diseases such as peri-implant mucositis and peri-implantitis because of the risk of incomplete removal of the cement during fitting of the restoration which may go undetected. This article discusses the merits of using milled CAD/CAM customised abutments in the aesthetic zone and a technique to control the healing of the soft tissues around them so that the use of a modified preformed abutment fitted with provisional crowns to control the soft tissues may be avoided.

METHODS
Patient selection and History
The patient used in this study was a 48 year old female patient with no relevant medical history. She was a regular attender of the practice and did not smoke. Her presenting complaint was of a post retained crown at 8 which regularly failed.

On examination, there was very little coronal ferrule evident and evidence of a cracked root. The diagnosis of vertical root fracture was made and the tooth was deemed unrestorable.

The patient had a medium-high smile line but a relatively thick biotype. Apart from some minor oral hygiene issues, the patient had a healthy mouth and no obvious periodontal disease. There was no obvious evidence of occlusal problems and no history of parafunction.

The various options of filling the gap at 8 were discussed with the patient, such as a removable denture, Maryland Bridge or tooth supported bridge. The patient did not want a removable denture as a long term solution or the potential unreliability of a Maryland bridge. A conventional tooth supported bridge would have been far too destructive of the unrestored 8 and 9. Written consent was therefore obtained for the implant option.

Initial treatment
At the initial appointment, an impression using addition cured silicone putty was taken in order to make an immediate Maryland bridge. At the following appointment, the offending post crown at 11 was extracted asatraumatically as possible under local anaesthetic (2% Lignocaine and 1/8000 adrenaline, buccal and palatal infiltrations) using periotomes and luxators. Post extraction socket mapping confirmed that the buccal plate had been preserved.

The space at 8 was temporarily filled with an immediate Maryland bridge, with lingual retainers on 8 and 9.
Surgical Phase
An “Early placement” protocol, as described by Buser et al.3, was planned so the implant placement was scheduled for 8 weeks post-extraction. Consent for the likely use of a bovine bone filler and porcine collagen membrane were obtained.

A prophylactic dose of 3g Amoxicillin was administered 1 hour pre-op. The patient was also given a pre-op mouth rinse with Corsodyl immediately pre-op. Local anaesthetic using 2% lignocaine and 1/80000 adrenaline was administered buccally and palatally. Aseptic conditions were observed throughout. The implant was placed using the standard Astratech surgical protocol. Figures 1 and 2 show the stages of the surgery.
Preliminary Laboratory Procedures

The preliminary model was cast from the impression taken at first stage surgery upon which the technician did a wax up of the anticipated soft tissue healing (Fig 3). A pre-surgical photograph was used by the technician to determine the correct levels of the soft tissues in the edentulous space as well as the adjacent teeth as these references are obviously lost by raising the flap during surgery.

A Soft tissue model was then cast and emergence profile sculpted using
pre-op photograph to determine position of gingival zenith at UR1 (Fig 4).

At this point the model was then scanned and sent to Atlantis to be programmed into their Virtual Abutment Design (VAD) software (Fig 5). A Gold-Hue Atlantis abutment and Duplicate abutment were ordered (Fig 6). As the emergence profile was being dictated by the soft tissue model sculpted by the technician, a prescription of “no tissue displacement” was made. A provisional acrylic crown was also ordered.

Restorative Phase
A period of 3 months was allowed before carrying out second stage surgery. As the impression had been taken during first stage surgery, this allowed either the Atlantis abutment or the Duplicate abutment, along with the provisional crown, to be fitted as a customised healing abutment at second stage surgery rather than using a traditional healing abutment. A period of 8 weeks soft tissue maturation was then allowed to pass at which point the patient was reviewed. The results are shown in figure 7.
RESULTS
The following image (fig 8) was taken 8 weeks after the Atlantis abutment and provisional crown had been fitted at second stage. The final shape of the provisional was refined using composite and an alginate matrix was taken to convey the desired shape to the laboratory. As the position of the soft tissues was satisfactory around the provisional, it was NOT necessary to take a further impression of the abutment. The technician simply made the final crown on the Duplicate abutment mounted on the working model. An Emax crown was ordered to the desired shading and characteristics. The final result is shown in Figure 9.

DISCUSSION
The Practice of using a modified pre-formed Abutment and a Provisional crown to control the soft tissues in the aesthetic zone is widely accepted and used in implant dentistry, and without question, can achieve some excellent results. But this technique comes with a biological compromise in that by default, the cement margin will be more subgingival and in some cases can be right next to the crestal bone.

This point is illustrated by the peri-apical radiograph above (fig 10) which was taken immediately after cementation. Although the radiograph doesn’t show any retained cement interdentally, it is impossible to determine whether it has been removed thoroughly, buccally and palatally. When the cement margin is particularly deep, it can also be very difficult to determine retained cement by clinical examination, even in the hands of experienced clinicians. From a more practical point of view, the modification of the pre-formed abutments in order to allow the correct emergence profile with the crown, often leaves them with a reduced surface area for bonding. This means that the crowns are far more likely to debond and will be troublesome to recement as the soft tissues will rapidly collapse onto the exposed abutment. This in itself compromises the peri-implant tissues as there is a risk of the implant crown not being fully re-seated during re-cementation.

These risks are substantially reduced with the type of milled CAD/CAM customised abutment used in this case study because the cement margin is usually far less subgingival (fig 11). This particular abutment system uses the principle of reverse treatment planning during the manufacture and is generated from a Virtual idealised wax-up of the final restoration. Because this virtual wax up determines the position of the cement margin of the final crown, it is the customised abutment that dictates the emergence profile, rather than the crown. The additional benefit of this method of design is that these abutments balance allowing sufficient space for material for technician to deliver an aesthetic restoration with maximum surface area for bonding of the restoration.

But the biological benefits of a customised abutment aside, until now there was no way of controlling the soft tissues with a customised abutment, without remaking the abutment with a different emergence profile. With this technique, the huge benefit of taking the impression during first stage surgery is that the Atlantis abutment can be used as a customised healing abutment. If after a period of soft tissue healing there is no change and there is a desirable aesthetic result, the technician can manufacture the final crown on the Duplicate abutment without the dentist having to remove the Atlantis abutment from the patient’s
mouth. Evidence suggests that this is biologically advantageous as any epithelial attachment to the abutment will not be disturbed and the implant interface will not get re-contaminated.\textsuperscript{4}

If however there has been a little soft tissue change such that the cement margin is slightly exposed, the \textit{Atlantis} abutment can be modified so that the cement margin is finished slightly subgingival and then returned to the technician for the final crown to made. The \textit{Duplicate} Abutment can then be placed in the patient’s mouth to support the provisional crown thus maintaining the same soft tissue emergence that has been created. Without the \textit{Duplicate} abutment, a standard healing abutment would have to be placed which would change the soft tissue emergence that had been created which could be detrimental to the final aesthetic result.

In the event that there is too much soft tissue and some recession is desired, the dentist still has the option to request that the buccal aspect of the \textit{Atlantis} Abutment is finished slightly more subgingival so that the crown can be designed to place some pressure on the buccal tissues to induce some recession. Obviously the surgeon must then take great care during the cementation of the crown to ensure that no cement is left subgingivally.

In the cases we have done using this technique so far, our experience is that there has only been very slight recession defects which have not been detrimental to the final aesthetic result. The greatest care has been taken during the planning of these cases to ensure that any buccal deficiencies in the bony ridge have been identified and treated accordingly (usually using Guided Bone Regeneration)\textsuperscript{3} prior to or during implant placement so that there was no risk of having a recession defect. Any Class III of IV bone defects (Cawood and Howell classification)\textsuperscript{5} left untreated will result in a compromised aesthetic result regardless of technique used.

The use of the \textit{Duplicate} abutment is cost effective for the surgeon and costs roughly the same as a new healing abutment. It must however be ordered at the same time as the \textit{Atlantis} abutment. The \textit{Duplicate} abutment is available in the \textit{Titanium} and \textit{Gold Hue} versions of the \textit{Atlantis} abutment system.

\textbf{CONCLUSIONS}

The use of this technique allows the surgeon to use an abutment system whereby the abutment is generated from an idealised virtual wax-up. This ensures that the abutment has a maximum surface area for bonding but still with enough space for the technician to manufacture an aesthetic crown and a cement margin which is only just subgingival. This allows easier cementation of the restoration and reduces the risk of peri-implant mucosal problems such as peri-implant mucositis and peri-implantitis. The use of the \textit{Atlantis} and \textit{Duplicate} abutments and all the biological advantages they bring, allows the surgeon some control of the soft tissues in the aesthetic zone so that the use of a modified pre-formed abutment and provisional crown with a deep cement margin can be avoided.

\textbf{Correspondence:}

Dr Tim Doswell
BChD Dip.Imp.Dent.RCS
http://www.raglansuite.co.uk
Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

References
With the increased popularity of implants and focus on esthetics, there is great emphasis on idealized bone foundation and soft tissue contours. The goal of reconstructive procedures is to provide ideal peri-implant bone that supports and maintains gingival contours. Here we present a case with alveolar ridge deficiency in the maxillary anterior region and the surgical procedure done to achieve final platform for implant placement.

**KEY WORDS:** Dental implants, ridge augmentation, reconstructive procedure, bone graft

1. Professor, Department of Prosthodontics, KDDC, Mathura, India
2. Private Practice, New Delhi, India
3. Post Graduate Student, Department of Prosthodontics, KDDC, Mathura, India
INTRODUCTION
Clinical management of missing teeth with dental implants has become common and well accepted. With current techniques and protocols, success of dental implants is more than 90 percent in both the maxilla and mandible, with even higher success in the anterior regions.\(^1, 2\) With the increased popularity of dental implants and a paradigm shift from restoring function to restoring form and function, there has been a greater emphasis on establishing idealized bone foundation and soft tissue contours for optimal esthetic results. Specifically for dental implants in the esthetic zone, intact papillae with ideal facial gingival contours that are indistinguishable from adjacent natural teeth are the goals of therapy and demands of patients. The goal of hard tissue augmentation is to provide a foundation for ideal implant placement that not only allows for biomechanically sound implant positioning, but also supports soft tissue for optimal esthetics.
Lahori et al

CASE REPORT

AN 18-year-old male reported to the outpatient dental department of K.D. Dental College & Hospital Mathura, with missing upper right and left central incisors, and upper left lateral incisor (Figures 1a, 1b). The patient gave a history of trauma due to a car accident which resulted in loss of some anterior teeth. On clinical examination, deficiency in the anterior residual alveolar ridge with loss of buccal cortical plate was noted. The patient was otherwise in good general health and was a non-smoker. The patient presented with his natural dentition in good condition. On examination there were no clinical signs of periodontitis or dental caries. The clinical findings were confirmed in the radiographic examination. After thorough examination, oral prophylaxis was done then diagnostic impressions were made with irreversible hydrocol-

Figure 4a: Clinical view of dental implant placement.

Figure 5: Xenograft placed for guided bone regeneration.

Figure 6: Trimmed guided bone regeneration barrier.

Figure 4b: Radiographic view of dental implant placement.
Figure 7: Guided bone regeneration barrier placed at surgical site.

Figure 8: Primary surgical closure.

Figure 9a: Radiograph at 4 months healing.

Figure 9b: Clinical view (facial) at 4 months healing.

Figure 9c: Clinical view (occlusal) at 4 months healing.

Figure 10: Soft tissue sculpting from dental implant abutments.
loid. The upper right and left central incisor, and upper left lateral incisor were missing and the edentulous ridge in this region was insufficient in both width and height for 3rd implant placement. The remaining teeth were vital and in good health.

TREATMENT PLANNING
The patient was informed about the lack of sufficient bone in the upper front teeth region. The different treatment modalities that were available were described. These included bone augmentation, implant placement and implant supported prosthesis. Further, the anticipated long-term result and alternative treatment options were discussed. After having evaluated the options, it was decided that a ridge augmentation procedure including guided bone regeneration (GBR) should be performed with subsequent implant placement and prosthetic reconstruction.

TREATMENT: Initial therapy
This treatment included patient information, oral hygiene instruction and professional tooth debridement.
Ridge Augmentation with Simultaneous Implant Placement:
A full thickness mucoperiosteal flap was elevated both buccally and palatally and extended from tooth 6 to tooth 11 (Figure 2). Osteotomies were done (Figure 3) with the placement of implants (Figures 4a, 4b). Bone graft (Alpha BIoS) was selected and was mixed with saline and placed on the ridge in the bony defect and was well adapted so that full concavity was restored (Figure 5). A guided bone regeneration (resorbable collagen membrane) membrane (Figure 6) was adapted and fixed to the edentulous bone crest (Figure 7). Releasing incisions were placed in the periosteum to reduce the tension and the flaps were closed with horizontal mattress and interrupted sutures (Figure 8). The sutures were removed after 2 weeks.

DISCUSSION
Ridge augmentation procedures should be performed in a proper surgical set-up and in patients with a dentition free of signs of destructive periodontitis. Before the surgical session, the perioral skin should be cleaned with the use of a disinfectant and the patient should rinse his or her mouth for 2 minutes with a 0.12-0.2% solution of chlorhexidine gluconate. The patient is subsequently covered with sterile sheets to minimize bacterial contamination from extraoral sites. The surgical procedure is in most cases performed on a lightly sedated patient and under local anesthesia.

A full thickness crestal incision is placed within the keratinized mucosa of the edentulous ridge. In a partially dentate patient the crestal incision is extended into an intrasulcular incision, mesially and/or distally, to involve one or two adjacent teeth. Vertical releasing incisions are made at the mesial and distal ends of the crestal incision. In order to get proper access to the surgical site the releasing incisions are frequently made in buccal as well as in lingual (palatal) direction. Once exposed, the cortical bone at the recipient site is curetted with a chisel to remove all remnants of granulation tissue and portions of adherent periosteum.

Guided Bone regeneration in membrane protected defects, heal in a sequence of steps that stimulate bone formation after tooth extraction. After blood clot formation, bone regeneration is initiated by the formation of woven bone initially along new blood vasculature at the periphery of the defect. Membranes have
been manufactured from biocompatible materials that are both nonresorbable and resorbable.

A barrier membrane frequently used in ridge augmentation procedures is made of expanded polytetrafluoroethylene (e-PTFE; Gore-Tex, W.L. Gore Ass., Flagstaff, AZ, US) and often the titanium reinforced variety of the e-PTFE membrane (TR GTAM; Gore-Tex, W.L. Gore Ass. Flagstaff, AZ, USA) is placed to obtain optimal stability of the wound in the recipient site.

Xenograft material was used in this patient (Alpha bios graft-Germany). Bone graft materials have been used to facilitate bone formation within a given space by occupying that space and allowing the subsequent bone growth. Natural bovine bone is a highly reliable and dimensionally stable, purified grafting material. The mineral composition, three dimensional structure and the physico-chemical and biological properties of natural bovine bone are similar to those of human bone. The unique manufacturing process for this xenograft involves high-temperature heating. The process removes all organic components and eliminates all potential immunological reactions.

The patient was recalled for follow-up after 1 month, 3 months, 4 months, and 6 months (Figures 9a-c). After 6 months healing abutments were placed for 3 weeks to achieve the soft tissue profile (Figure 10). After 3 weeks, a closed tray impression (Figure 11a) was made with rubber base impression material (Figure 11b). The impression was sent to the laboratory for the final prosthesis (Figures 12a, 12b). The final implant prosthesis placed six months after implant placement (Figures 13a, 13b).

CONCLUSION

This case describes the different phases included in the surgical reconstruction of a site which included three missing maxillary teeth. In this particular case the esthetic outcome was of great importance. Therefore, a number of different procedures were required to reconstruct both the hard and the soft tissues.

References

Ease of drilling sequence – Minimized drill sequence (2~4 drills) allows precision of osteotomy site preparation and less chair time for both dental surgeons and patients.

Color coding – Implant vials and drills are color coded to eliminate confusion.

Wide selections – Wide selection of implant sizes and prosthetic options are available to meet the needs of all dental surgeons.

Call now to learn more
888.446.9995

Support
support@osseofuse.com

Dental Implant System You Can Depend On

Background: Reconstruction of missing teeth in posterior areas has been always hampered by the limited bone availability and insufficient bone quality. The aim this paper was to assess the clinical and radiological performance of short (6.5mm) implants inserted in the premolar and molar regions of the maxilla. Implants were restored as single crowns or fixed span bridges and followed up for 2 years.

Methods: Reported are the results of a prospective case series. Included patients had to show a vertical bone height 6.5 - 8.0mm as well as a minimal bone width of 6.0 mm. Implant stability was assessed by tactile investigation. Periapical X-ray’s were evaluated 6 months and 2 years after implant placement.

Results: 56 patients have received 77 short Titanium implants. Radiographic evaluation of the peri-implant bone height confirmed the remarkably stable bone level related to the use of the implant line. The peri-implant bone level stabilized at 0.9 ± 0.5 mm (mean ± standard deviation) beneath the microgap i.e. implant-abutment connection. A case is included that documents the favorable clinical outcome obtained with short implants.

Conclusions: Within the limitations of this case series, the reliable and predictable use of short implants for up to 2 years was confirmed. The results obtained in a multi-center setting confirmed the positive observations reported by other authors. Minimal periapical bone loss (<1mm) has been found radiographically. Long term studies are still needed to reveal if there are any specific risk factors pertinent to the use of short implants.

KEY WORDS: Dental implants, short dental implants, success rates
BACKGROUND

The reconstruction of missing teeth in posterior areas has been always hampered by the limited bone availability and insufficient bone quality typically found in the posterior regions due to post extraction bone atrophy both apico-occlusally and bucco-palatally, pneumatized sinus etc. Additional factors such as significant functional forces in the posterior segments of the maxilla increase the failure risk of implant placement. Similar anatomical limitations are mentioned in the recent review by Estefanous et al. The restoration of implants in posterior areas is more complex if e.g. permanent teeth were lost at young age, due to weak bone quality (D3 and D4), enhanced bone resorption due to mucous stimuli and the presence of anatomic structures such as sinus cavity or inferior alveolar nerve, etc. Particularly in the maxilla the use of short implants i.e. < 7mm long (endosseous part), is advantageous to avoid the need for sinus floor augmentation (sinus lift). Several bone augmenting techniques have been developed with the goal of increasing the bone volume before implant placement thereby allowing the use of longer and wider diameter implants. The surgical problems and potential failures of such techniques have been clinically extensively documented. The placement of shorter implants has the potential to avoid the need for such techniques. This would be beneficial for the patients both in terms of less morbidity as well as economically. Despite the fact that early papers on short implants reported higher implant loss rates, recent systematic literature reviews stated that initial survival rates were comparable to longer implants and thus constitute a viable alternative to additional augmentation procedures. This correlates well with the fact that model calculations by Finite Element Analysis (FEA) indicate clearly that the distribution of horizontal and vertical loading forces is similar to longer implants. Other calculations have also shown that bone stress should be virtually independent from implant length; a more important role was assigned to implant diameter. More recent reports indicated that it is possible to achieve highly acceptable implant survival rates with the current short implants. Stellingsma et al. have shown survival rates of 88 to 100% in atrophied mandible. A survival rate of 96% was reported for short implants in severely atrophic maxilla. Esposito et al. in a randomized, parallel group study compared the 3 year post loading outcome of short and long (with guided bone regeneration) implants. They have concluded that in cases with limited residual bone of 7 - 8mm over the mandibular canal short implants are an interesting alternative to vertical augmentation. The treatment is faster, cheaper and related to less morbidity. It is to be noted that implant insertion into pristine bone was compared to implants placed after preliminary sinus lift elevation. In this prospective study that included 393 implants and 155 patients treated in two groups, the implants placed in augmented sinuses had a lower survival rate compared to implants placed in pristine bone.

Excessive crown-implant ratios have been discussed to be detrimental to long term withdrawal. For obvious reasons this ratio needs particular attention when using short implants. Birdi et al. determined the crown-implant ratios of 309 single tooth implant supported restorations on short implants. The mean follow up time was 21 months. The mean crown-implant ratio was 2.0 i.e. quite unfavorable for a tooth. No statistically significant relationship was found between the crown-implant ratio and neither implant suc-
De Santis et al. have studied short implants (≤8.5mm) placed in posterior edentulous areas, predominantly in the mandible, that were affected by high bone resorption. After 1 - 3 years follow up they have found a survival rate of 98.1% i.e. only 2 of 107 implants have been lost, and a success rate of 96.3% i.e. only 4 of 107 implants failed the predefined success criteria. The results of this study are therefore also in favor of using short implants in posterior areas with highly resorbed bone. In this context it is important to be aware that the implant length used by Brånemark et al. in their original protocol was established empirically. The implants at that time had machined (smooth) endosseal surface. Currently used implants with microstructured endosseal surfaces are characterized by improved osseointegration and increased amount of bone-to-implant contacts. Together with optimized geometry, contemporary implants are superior in maintaining implant stability. This in turn should allow the use of shorter implants. Short implants are typically described as <10 mm long, but Hagi et al. have described short implants as <7.0mm long. This is more practicable as implants >8.0mm were commonly used for a long time without any particular problem related to their length.

In a recent review on meta-analysis of short implant survival studies, it was concluded that “the majority of studies obtain a CSR similar to that of longer implants (92.5% - 98.42% for machined and rough surface implants, respectively)” and “... rehabilitations with short implants are a reliable treatment”. This conclusion is to be understood within the limitations of a meta-analysis and the lack of well designed, randomized trials. A similar conclusion was drawn by Telleman et al. from their systematic literature review of survival rate of 2611 short implants that were installed in partially edentulous patients. Nevertheless the authors have found an increase in implant survival (from 93.1% to 98.6%) that was associated with increasing implant length (from 5.0mm to 9.5mm). The authors believe that there is fair evidence that short implants can be placed in the partially edentulous patient, although with a tendency towards an increasing survival rate per implant length and a better prognosis in the mandible of non-smokers. Morand and Irinakis in their earlier literature review also concluded that “... although (short implants) are commonly used in the areas of the mouth under increased stress (posterior region), their success rate mimic those of longer implants when careful case selection criteria have been used”. Last but not least Anniwali et al. concluded their systematic review on short implants that “The provision of short implant-supported prostheses in patients with atrophic alveolar ridges appears to be a successful treatment option in the short-term; however more evidence is needed for the long term”.

The aim this paper is to assess the clinical and radiological performance of short (6.5mm) implants inserted in the premolar and molar regions of the maxilla. The residual bone volume showed a bone height was at least 6.5mm and bone width at least 6mm. They were restored as single crowns or fixed span bridges and followed up for 2 years after insertion.

**METHODS**

**Patients**

This prospective case series included 56 consecutive patients (35 females / 21 males) referred for dental implantation to three different practices.
(JNH, JH, DA). Patients were entered into the study consecutively i.e. with no specific selection criteria apart from the routine assessment of their suitability to undergo implant surgery. Patients with good overall physical status (ASA PS1 or PS2), had at least one missing tooth in positions 15 - 17, 25 - 27, 35 - 37, or 44 - 47. At the implant site they had to show a vertical bone height between 6.5mm and 8mm as well as a minimal bone width of 6 mm, assessed by virtual implant placement using Simplant® software (Materialise, France). This is based on a native image obtained by cone beam computed tomography (CBCT). Particular attention was given to keep a 2mm safety zone from the mental nerve to avoid any trauma during the surgery due to an initial radiographic error. Moreover, patients they had to present with a normal occlusion (no open bite) including an opposing arch offering adequate occlusal support. Care was taken not to insert the implants in heavy smokers (>5 cigarettes per day), patients with heavy bruxism, untreated periodontal disease, poor plaque control or a position where an implant was lost previously. Implants were inserted into healed bone i.e. the tooth extraction had to be done at least 3 months before implant insertion. No crestal bone augmentation was performed.

The patients were informed about all available alternative therapeutic options. They were included only if they chose short implants treatment. The participating patients were therefore not exposed to any additional risk and this case series was therefore not qualified as research. In compliance with valid ethical requirements (Declaration of Helsinki, current edition), the patients were instructed about the details of their participation and a written Informed Consent was explained and signed prior to any intervention.

**Surgical procedure**

Standard surgical one stage procedure was performed under local anesthesia. Patients received antibiotic premedication one hour before surgery (2gr amoxicillin or 600mg clindamycin if allergic to penicillin) and rinsed for 1 min with 0.15% chlorhexidine mouth wash. Drilling protocol was performed according to manufacturer’s recommendations. Bone quality (D1-D4; Misch classification) was recorded in patient’s chart. The insertion depth of the implant was driven by the anatomy of the surrounding bone: particular attention was given to avoid any rough surface to be in contact with soft tissue. Implants placed were 6.5mm long titanium implants with a 1 mm polished collar, platform diameters 4.0, 4.5, 5.0 or 6.0mm and hydrophilic, moderately rough enossal surface.

At the end of the surgery, patients were instructed to use standard mouth hygiene procedures including chlorhexidine mouth wash immediately after implantation. Paracetamol 1gr every 6 hours was given for 48 hours. No antibiotic nor antiinflammatory medication were prescribed after implant placement. Sutures were removed after one week.

**Restoration**

Implants were occlusaly loaded with resin temporary crowns between 8 and 12 weeks post surgery. For permanent prosthetics, patients were referred back to their dentist at least 2 months later. As a result, some of the restorations were still provisional by the final examination.
Implant stability

Implant stability was assessed by tactile investigation. The implants were considered to be stable in the absence of any signs of mobility, pocketing and in the absence of bleeding on probing or pain during the investigation.

Follow up

The patients were followed up 2 months after loading and following visits were scheduled at least once per year. Routine follow up program eventually included oral hygiene reinforcement, scaling and X-rays (when needed).

Radiographic marginal bone level assessment

Routine periapical X-rays were deemed to be not necessary therefore they were taken at 6 months and 2 years post surgery to check uneventful osseointegration. Care was taken to use the parallel-perpendicular technique i.e. the sensor holder was placed parallel and the X-ray tube perpendicular to the implant axis to ensure optimal projection for each patient. Particular attention was given to obtain an X-ray that would show the apex of the implant and the occlusal aspect of the crown in order to evaluate the clinical root/crown ratio. Along with the clinical check the X-rays have been used for quantitative bone level evaluation. This was done by a single evaluator (PZ) using ImageJ (NIH, USA, current version). The images were scaled using the known implant thread height.27

RESULTS

56 patients have received 77 short implants in this report. The average patient age at implantation was 59 (34 - 77) years. One patient was on anticoagulant therapy and one had a cardiovascular disease. Two patients underwent simultaneous bone augmentation with deproteinized bovine bone mineral (DBBM) and autogenous bone as filling material. 43 (56%) implants have been placed in the maxilla (FDI 15-17, 25 - 27) and 34 (44%) in the mandible (FDI 35-37, 45-47). From the 77 inserted 6.5mm long implants, 16 (21%) had platform diameter 4.0mm, 37 (48%) 4.5mm, 17 (22%) 5.0mm and 7 (9%) a platform diameter of 6.0mm. In two of the three participating centers (DA, JH) the maximal insertion torque was recorded (40 implants). 16 implants (40%) were inserted at 20 Ncm, 22 implants (55%) at 30 Ncm and 2 implants (5%) at 35 Ncm, suggesting good bone healing at inserted sites. This corresponded well with the fact that no implant was lost i.e. apparent 100% implant survival rate.

The radiographic evaluation of the peri-implant bone height confirmed the remarkably stable bone level related to the use of this implant line (Figure 1).27, 28, 29 The peri-implant bone level stabilized at 0.9 ± 0.5 mm (mean ± standard deviations) beneath the microgap i.e. implant-abutment connection. The used implants have a 1mm high machined collar therefore also in this patient population the bone level has stabilized at the interface to the moderately rough enossal surface.

One patient, a 74 year old female of the cohort reported above, presented with partially edentulous right posterior mandible. The teeth had been extracted more than 3 months ago i.e. three ELEMENT RC INICELL implants have been placed into healed sites. Due to the limited distance of the nerve channel i.e. to avoid the risk of its injury, “short” implants were inserted in replacement of the second premolar and first molar...
teeth (positions 45 and 46, respectively). The implants were covered with healing abutments. After 2 months of uneventful trans-gingival (non-submerged) healing, the healing abutments were removed (Figure 2). This picture also documents that the soft tissue around the implants was fully conditioned. A periapical X-ray was taken that confirmed the absence of any pathological signs (not shown). An open-tray impression was taken. The framework was screw-attached to ensure that passive fit was achieved, the occlusion checked and the permanent restoration (Fig. 3) completed and screw attached within two weeks after removal of the healing abutments. An intraoral picture taken after 2 years of function documents the very favorable and predictable outcome (Fig. 4).

**DISCUSSION**

Recently, short dental implants have proved to be as successful as longer implants. This improvement\(^{30}\) can be explained by more exact indications and consequently improved initial diagnosis resulting from the widespread use of CBCT that is available since the turn of the century, improved implant design and our ability to identify risk factors related to periimplantitis.\(^{31,32}\) The availability of more accurate diagnostic tools that enable more widespread manufacturing of (precise) surgical guides have contributed to the increased survival and success of short implants. This improvement in hard tissue management was accompanied by more precise soft tissue diagnosis (thin biotype) management which in turn may have also contributed to the improved survival and success.
rates observed in more recent publications. Studies using finite element analysis tend to show that highest strains are only exerted on the crestal part of the dental implant, whereas little forces are transmitted to the apical part. Following this rule longer implant thus should not show any mechanical advantage, if only this aspect would be considered. This particular point is supported by the results of the presented case series. We have demonstrated that success of short implants is similar to long ones. Moreover, the implant/crown ratio < 2 does not seem to have any importance, leaving open the question of the need to splint short to long implants. It supports the feasibility of treating single missing teeth by short implants. The results of the assessment of short dental implants restored as single unit non-splinted crowns has been published quite recently.\textsuperscript{33} In this clinical investigation 221 short (6-9mm; diameters 3.7-5.6mm) implants placed and restored on 168 patients have been followed for 27 months. The survival rate in the maxilla was 88.6% whereas it was 96.0% in the mandible. Cigarette smoking, diabetes mellitus and bone augmentation procedures were not associated with (early) implant failure rate. The authors have concluded that the survival rate of short implants restored as single crowns over an average of 37 months was favorable and comparable with longer implants.

The attached case documents the high predictability of the selected treatment protocol (Figs. 2 - 4.) Without the availability of short implants a much more invasive surgical protocol would have been needed. Consequently a signif-

**Figure 2:** Three implants placed in the right mandible. The healing abutments were removed after 2 months of trans-gingival healing.
significant clinical risk was avoided and the treatment was also more advantageous economically.

The eventual development of peri-implantitis remains a major problem. Two factors are to be considered: the ability to provide an optimal plaque control which may be difficult due to the posterior location of these implants and the adequate periodontal support. This aspect should be addressed by appropriate hard and soft tissue management i.e. ensuring sufficient surrounding bone on facial and lingual/palatal aspects and optimal soft tissue biotype.

**CONCLUSIONS**

Within the limitations of this case series, the reliable and predictable use of short implants for up to 2 years was confirmed. The results obtained in a multi-center setting confirmed the positive observations reported by other authors. Minimal periapical bone loss (<1mm) has been found radiographically. Long term studies are still needed to reveal if there are any specific risk factors pertinent to the use of short implants.

**Correspondence:**

Dr. Jean-Nicholas Hasson  
5, rue du Werkhof  
F-68100 Mulhouse  
France  
+33 (3) 89 45 89 84  
+33 (3) 89 56 31 12  
hasson@hrnet.fr
Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

References
ADVERTISE WITH JIACD TODAY!

Reach more customers with the dental profession’s first truly interactive paperless journal!

Using revolutionary online technology, JIACD provides its readers with an experience that is simply not available with traditional hard copy paper journals.

WWW.JIACD.COM