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Implantology in the year of IDS

Prof Dr Dr Frank Palm

_**The 34th International Dental Show (IDS)** in Cologne is just around the corner, bringing with it a challenging test for the international dental market. This dental show continues to grow, with approximately 1,900 exhibitors from 55 countries presenting their products in ten exhibition halls this year. We wait to see if an economic rebound has taken place, and if certain undesirable developments have been corrected.

The implantology market in particular suffered from volatility triggered by the financial crisis, and it is still not clear whether the industry can return to double digit growth rates in 2011. Considering the positive developments in the industry in the autumn of last year, and the high attendance numbers at this year's congresses and trade shows, many implantologists are optimistic. In particular, implant suppliers are keen to make a new start, and the IDS should provide a glittering display of innovations and numerous product launches. Digitalization in implantology, from 3-D diagnosis, digital dental impression-taking and computer-aided planning and navigation, through to prosthetic restorations manufactured by means of CAD/CAM, are likely to be the center of attention. Moreover, new and further developments in implant materials and designs, as well as new approaches to solutions for regenerative techniques will play an important role.

These developments provoke our curiosity, though it is clear that we cannot expect an "optimal solution" for all medical indications and a "golden standard" in implantology in the near future. Rather, many factors are important when it comes to finding the best solution for each individual case. Limiting factors on the patient's part e.g. funding, time, personal requirements, physical and psychological capacities, and most of all the skills of the dentist, are the most important criteria. Without the expert skills of a competent and experienced implantologist the best technique is useless. As an association of experts, it is our job to expose colleagues to this topic more intensely, and to ensure that the existing high standards in implantology are maintained in future.

Like all other important implantological associations, DGZI will be present at the IDS with its own stand, and we would be pleased and look forward to meeting you.

Prof Dr Dr Frank Palm
President of the DGZI
(German Association of Dental Implantology)

Chief Physician, Department of Oral and Maxillofacial Surgery,
Clinical Center Constance, Germany


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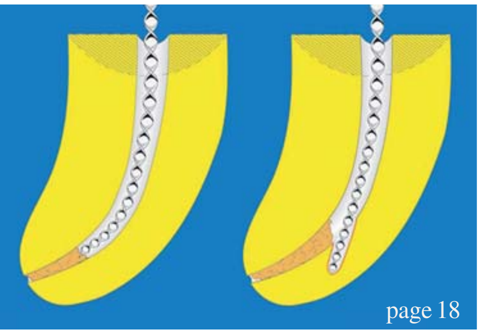
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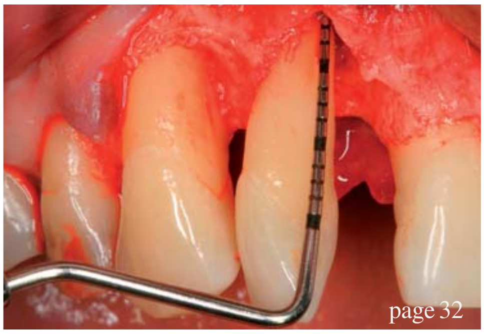
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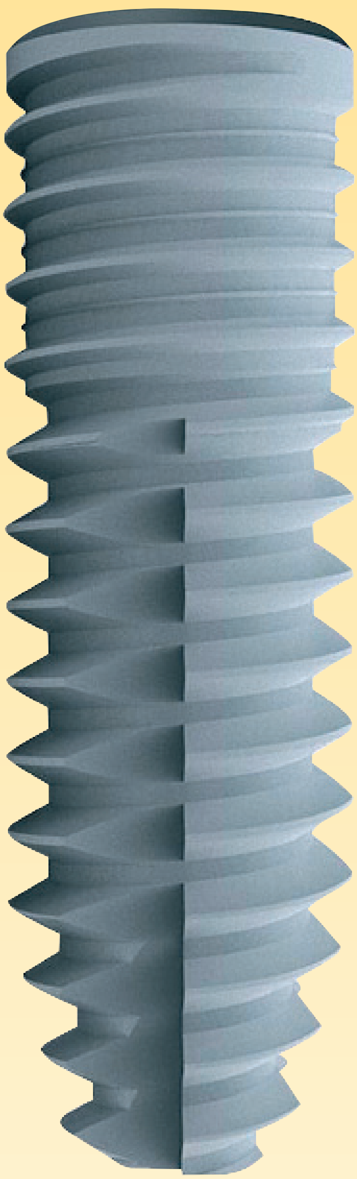

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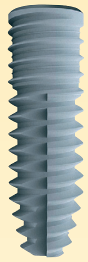

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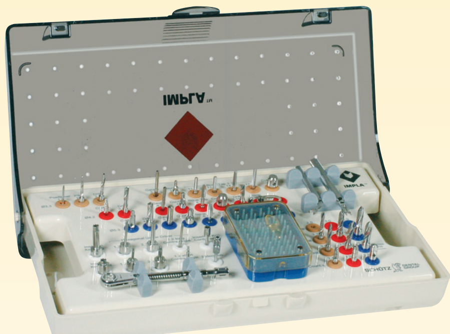

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Biomechanical finite element analysis of small diameter and short dental implant

Authors_Istabrak Hasan[1], Dr Friedhelm Heinemann[2], Maria Aitlahrach[1] and Prof Dr Christoph Bourauel[1]

_Abstract

Short and mini dental implants have been widely used as treatment alternatives in certain selected clinical situations. However, a profound scientific analysis of the mechanical and biomechanical impact of the reduced length and diameter of these implant geometries has not been published until now. Using finite element analysis, a series of different experimentally designed short and mini implants have been analysed with regard to their load transfer to the alveolar bone and have been compared to respective standard commercial implants. Mini implants have been inserted in an idealised bone bed representing the anterior mandibular jaw region and loaded with a force of 150 N. An immediate loading condition was assumed and analysed using the contact analysis option of the FE package MSC.Marc/Mentat. Short implants were inserted in an idealised posterior bone segment and loaded in osseointegrated state with forces of 300 N. Clearly increased bone loading was observed for the short and mini dental implants compared with standard implants, clearly exceeding the physiological limit of 100 MPa. The determined biomechanical characteristics could explain the slightly increased failure rate of short and mini dental implants.

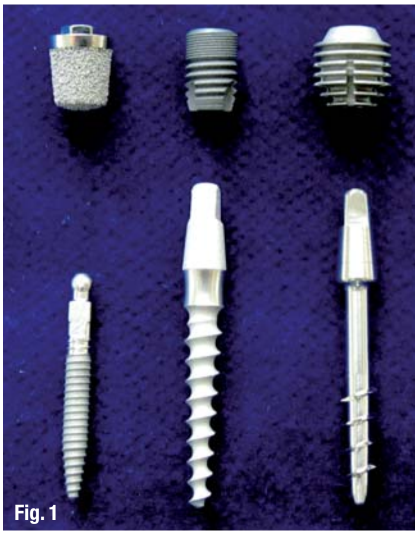

Fig. 1

Fig. 2

Fig. 1_Overview of some available commercial short and mini implants.
Fig. 2_Loading direction of the numerical models. A mini implant (2.5 x 15 mm) inserted in an idealised bone block with a cortical thickness of 1.2 mm (left) and a short implant (5.5 x 7 mm) inserted in an idealised bone block with a cortical thickness of 0.5 mm (right).

_Introduction

The loss of crestal bone around dental implants has been reported to be influenced by many factors. These include surgical trauma, implant abutment microgap, bacterial infection of peri-implant tissues and biomechanical factors related to loading. Factors that affect the load transfer at the bone implant interface include the type of loading, material properties of the implant and prosthesis, implant geometry, surface structure, quality and quantity of the surrounding bone, and nature of the bone-implant interface.[9] There are many dental implant designs available on the market for specific clinical applications: standard implants, short implants with wide diameter and implants with small diameters. All are available in different geometries, thread configurations (if any) and thread depth (Fig. 1).

After tooth loss, however, severely atrophic residual alveolar ridges are fairly common, especially in patients who have been edentulous for a long period of time. Posterior areas of the maxilla and the mandible are areas where clinicians have greater anatomical limitations. Reduced alveolar bone height very often represents a contraindication to implant therapy, unless a procedure such as ridge augmentation or sinus floor elevation is performed. Although widely utilised, these techniques imply greater morbidity, longer treatment times and higher costs. The sinus cavity in the maxilla and alveolar nerve proximity in the mandible are clinical situations where short implants could be considered as an alternative treatment option. Numerous

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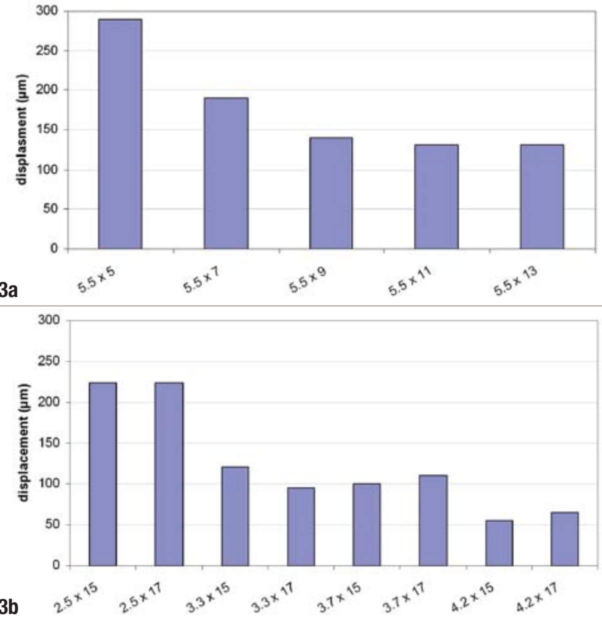

Fig. 3a

Fig. 3b

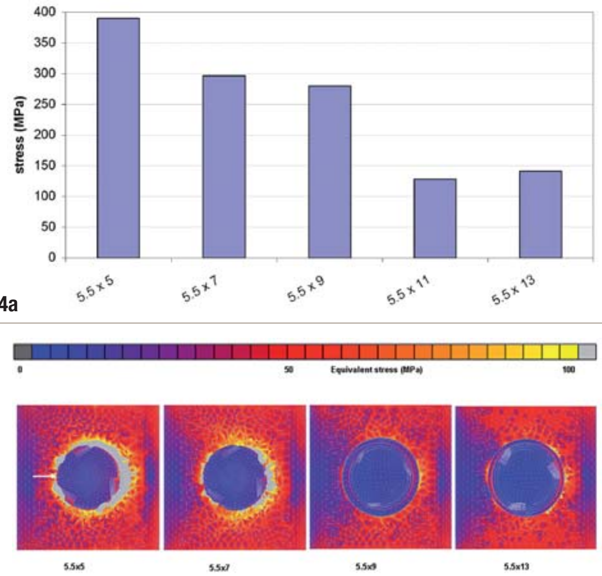

Fig. 4a

Fig. 4b

Fig. 3_Implant displacements obtained for (a) the short implants and the corresponding standard implants after loading of 300 N in 308 from the implant axis, (b) the MDIs and the corresponding standard implants after loading of 150 N in 308 from the implant axis.

Fig. 4_Total of equivalent stress obtained for the short implants and the corresponding standard implants. (a) Maximum values obtained at the cervical region of the alveolar bone, (b) occlusal view of the stress distribution. The arrow indicates the direction of the applied load.

short implants might have improved over the past few years.

In addition to standard and short implants, there are the implants of smaller diameters, which are called mini dental implants (MDIs). Those are generally 2.75 mm to 3.30 mm in diameter, and they are frequently used in cases of limited bone volume. Several MDIs exist with even smaller diameters, ranging from 1.8 mm to 2.4 mm.[28, 29] In the beginning, the main application of MDIs was to serve as the remedy and provisional instrument for insertion of provisional restorations during the osseointegration phase of conventional standard (larger diameter) endosseus implants.[1, 2, 12] The assumption was that MDIs are unable to provide functional load of implant supported prostheses.[2, 11] In the course of time, it was observed that those implants osseointegrated very well clinically.[12] It became clear that, in combination with a minimally invasive implant insertion protocol for the MDIs, they could provide a satisfactory prosthodontic rehabilitation effect.[12, 29]

The advantage in use of MDIs is the minimally invasive, single stage placement procedure[2, 11] in comparison to the procedure for conventional implants (diameter 3.5 and wider). The philosophy of MDI insertion is a minimally invasive technique of inserting the implant into the bone through a small opening of the soft tissue, but not a prepared bone site.[2,11] Therefore, the bone damage and bone wound during implantation is minimised. Bleeding and postoperative discomfort are reduced[12] and healing time is shortened. It is recommended to load such implants imme immediately.[2] The purpose of the present study was to numerically analyse the biomechanical differences of short and narrow (mini) dental implants to the standard ones according to their clinical applications. This study tested some of the available geometries for the narrow as well as short implants. The magnitude of micromotion of implants was investigated, in addition to the magnitude and distribution of stresses and strains in the alveolar bone around the implants.

_Materials and methods

A total of 13 three-dimensional finite element (FE) models were developed: two models for short implants, three for the corresponding standard implants, two for mini implants, and finally six models for the corresponding standard implants (Table I). The geometries of the implants were constructed from the CAD/CAM data that were generated and provided by a Dental Implant company and subsequently fed into the FE program MSC. Marc/Mentat 2008. According to several previous studies[15], the tetrahedral element type (4-nodes) was selected for model generation and the bone in its two components (cortical and cancellous bone) was meshed using a coarsening factor of 1.5 mm to gradually enlarge the tetrahedral element size from the implant contact region (0.2 mm) to the external surface (0.5 mm). As in the previous studies, the non-linear incremental Full Newton-Raphson solver was used15 running on a small Dell server cluster (Power Edge 1950, 20 cores, 40 GB RAM).

_Implant geometries of group 1 (short implants)

Two short implants were investigated with a diameter of 5.5 mm and a length of 5 mm and 7 mm, respectively. Three commercially available standard implants served for comparison: 5.5 x 9 mm, 5.5 x 11 mm, and 5.5 x 13 mm. According to their clinical applications, full osseointegrated condition was considered for the numerical analysis of the above-mentioned models. Young's modulus of the different components was chosen to match the bone quality in the anatomical regions (mandibulary and maxillary posterior bone) where the short implants are typically inserted: 110 GPa for the implants, 20 GPa for cortical bone, and 300 MPa for cancellous bone. Typically, short implants are inserted in the posterior jaw region, thus the cortical layer in the idealised bone model had a thickness of 0.5 mm.

_Implant geometries of group 2 (mini implants)

Two mini implants were studied with a diameter of 2.5 mm and a length of 15 mm and 17 mm, respectively. Six commercially available standard implants were used as a reference: 3.3 x 15 mm, 3.7 x 15 mm, 4.2 x 15 mm, 3.3 x 17 mm, 3.7 x 17 mm, and 4.2 x 17 mm. According to their clinical applications, immediate loading condition was considered for the numerical analysis of the mini implant models. This has been done by considering a contact situation at the bone implant interface. A Coulomb friction model with a coefficient of friction of 0.5 was selected for the contact analysis.[15]

Young's modulus of the different structures was chosen to be 110 GPa for the implants, 20 GPa for cortical bone, and 1,000 MPa for the cancellous bone. Typically, mini implants are inserted into the anterior mandibular jaw region, thus the cortical layers had a thickness of 1.2 mm.

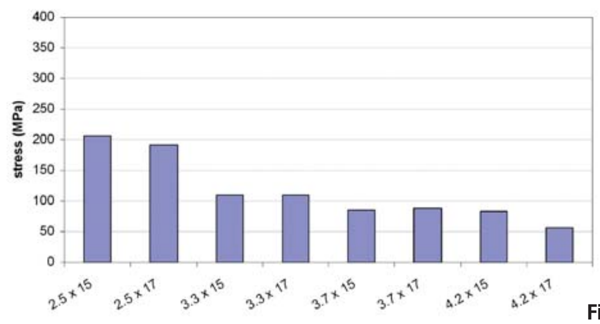

Fig. 5a

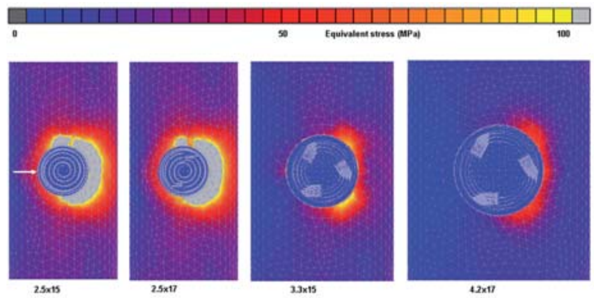

Fig. 5b

Fig. 5_Total of equivalent stress obtained for the MDIs and the corresponding standard implants. **(a)** Maximum values obtained at the cervical region of the alveolar bone, **(b)** occlusal view of the stress distribution. The arrow indicates the direction of the applied load.

Figure 2 displays the idealised bone segments with the inserted implants. The mini implants were inserted into the bone segments (left) such that the screw threads did touch the cortical bone. Short implants were combined with an idealised bone segment that ensured sufficient distance to the basal cortical layer to simulate adequate distance to the nerve canal. For the whole 13 models, implants were subjected to a load at an angle of 308 from the implant axis. Loading direction was adjusted analogous to the ISO standard 1480118. The magnitude of the applied force was 300 N for comparing group 1 and 150 N for comparing group 220. The end faces were constrained in all three degrees of freedom (Fig. 2).

Table 1_Description of the numerical models used in the study and their loading conditions.

Model	Loading condition	No. of elements	No. of nodes
Comparing group 1			
Shorty 5.5 x 5 mm	Delayed loading	116,167	22,315
Shorty 5.5 x 7 mm	Delayed loading	127,367	24,176
tioLogic 5.5 x 9 mm	Delayed loading	146,890	27,990
tioLogic 5.5 x 11 mm	Delayed loading	152,218	28,764
tioLogic 5.5 x 13 mm	Delayed loading	162,185	30,377
Comparing group 2			
Mini 2.5 x 15 mm	Immediate loading	151,851	34,870
Mini 2.5 x 17 mm	Immediate loading	179,773	41,481
tioLogic 3.3 x 15 mm	Immediate loading	127,569	27,685
tioLogic 3.3 x 17 mm	Immediate loading	141,938	30,925
tioLogic 3.7 x 15 mm	Immediate loading	136,560	29,650
tioLogic 3.7 x 17 mm	Immediate loading	148,259	32,245
tioLogic 4.2 x 15 mm	Immediate loading	145,351	31,427
tioLogic 4.2 x 17 mm	Immediate loading	167,624	20,393

Table I