Effect of diameter and length on stress distribution of the alveolar crest around immediate loading implants.

Ding X, Liao SH, Zhu XH, Zhang XH, Zhang L.


Abstract

BACKGROUND:

Many clinical observations have shown that immediate loading is indicated when the stabilization of the bone/implant is optimal and when the estimated loads are not excessively high. Nonetheless, more experimental studies are needed to consider the immediate loading protocol as a safe procedure. Mechanical analysis using the finite element (FE) method analysis has been employed by many authors to understand the biomechanical behavior around dental implants.

PURPOSE:

This study was to evaluate the effect of the diameter and length on the stress and strain distribution of the crestal bone around implants under immediate loading.

MATERIALS AND METHODS:

By an ad hoc automatic mesh generator, high-quality FE models of complete range mandible was constructed from computer tomography, with three Straumann (Straumann Institute, Waldenburg, Switzerland) implants of various sizes embedded in the anterior zone. The implant diameter ranged from 3.3 to 4.8 mm, and length ranged from 6 to 14 mm, resulting in seven designs. The implant-bone interface was simulated by nonlinear frictional contact algorithm. For each design, vertical and oblique loadings of 150 N were applied, respectively, to each implant, and stresses and strains in the surrounding cortical bone were evaluated.

RESULTS:

The biomechanics analysis provided results that the oblique loading would induce significantly higher interfacial stresses and strains than the vertical loading, while the intergroup stress difference significant levels was evaluated using t-tests method and the level of significance (.05) that was accepted for significance. Under both loadings, the maximal values were recorded in the 3.3 (diameter) x 10 (length) mm implant configuration, whose mean and peak values were both higher than that of others with significant statistical differences. The second maximal one is 4.1 x 6 mm configuration, and the minimal stresses were recorded in 4.8 x 10 mm configuration, whose strains were also near to lowest.

CONCLUSIONS:

Increasing the diameter and length of the implant decreased the stress and strain on the alveolar crest, and the stress and strain values notably increased under buccolingual loading.
as compared with vertical loading, but diameter had a more significant effect than length to relieve the crestal stress and strain concentration.

**Implant survival to 36 months as related to length and diameter.**

Winkler S, Morris HF, Ochi S.


**Abstract**

**BACKGROUND:**

It is generally accepted that diameter and length of an endosseous dental implant and its stability at placement are critical factors in achieving and maintaining osseointegration. In the event of slight implant mobility at placement, the conventional or accepted treatment is to place a longer implant and/or one of wider diameter. This manuscript presents stability and survival/failure data for implants of different diameters and lengths following 36 months post-placement, as well as crestal bone loss data between placement and uncovering.

**METHODS:**

A subset of the Dental Implant Clinical Research Group's database was used to study the 3-year survival and stability of various implant lengths (7 mm, 8 mm, 10 mm, 13 mm, and 16 mm) and diameters (3 mm+ and 4 mm+). Placement to uncovering crestal bone loss was also determined. The implants were generally representative of those available for clinical use (screws, basket, grooved, hydroxy-apatite-coated, CP-Ti, Ti-alloy). The study protocol specified that the implants be randomized to various jaw regions to accomplish the primary goals of the study—the comparison of each implant design's overall survival. A total of 2,917 implants were placed, restored, and followed. Data for all 3 mm to 3.9 mm diameter implants were pooled into a "3+" group, and the 4 mm to 4.9 mm diameter implants into a "4+" mm group. No attempt was made to look at the influence of any other variables on survival outcomes. The possible influence of clustering on survival was taken into consideration.

**RESULTS:**

The 3+ mm group had a mean stability (PTV) of -3.8 (SD = 2.9), and the 4+ group had a mean PTV of -4.4 (SD = 2.7) (P < 0.05). The PTVs for implant lengths ranged from -2.9 (SD = 2.8) for 7 mm lengths to -3.9 (SD = 2.9) for 16 mm lengths (P < 0.05). Survival to 36 months was 90.7% for the 3+ diameter and 94.6% for the 4+ group (P = 0.01). Survival ranged from 66.7% for the 7 mm implants to 96.4% for 16 mm implants (P = 0.001). Outcomes did not change when clustering was considered, although the P value decreased slightly.

**CONCLUSIONS:**

The results indicate that: 1) shorter implants had statistically lower survival rates as compared with longer implants; 2) 3+ mm diameter implants had a lower survival rate as compared with 4+ mm implants; 3) 3+ mm diameter implants are less stable (more positive PTVs) than 4+ mm implants; and 4) there was no significant difference in crestal bone loss for the two different implant diameters between placement and uncovering.
A 7-year life table analysis from a prospective study on ITI implants with special emphasis on the use of short implants. Results from a private practice.


Abstract

This paper reports on a 7-year life table analysis on ITI titanium plasma-sprayed (TPS) and sandblasted and etched (SLA) implants placed in a private practice and loaded for at least 1 year. In 236 patients, 528 (264 TPS and 264 SLA) implants were placed, 351 (66.5%) implants rehabilitated the posterior region and 71.1% implants were ≤11 mm. In the posterior mandible and maxilla, the mean implant length was 9.90 and 9.74 mm respectively. Implant length was determined through standard radiographs only. Increase of the number of implants or reduction of the width or length of the rehabilitations was no specifically sought for the shorter implants. One hundred and twenty-two SLA implants were loaded within 63 days. All early loaded SLA implants resisted the applied 35 N cm without rotation or pain. Three implants failed, one early and two late failures, all were SLA implants placed in the mandible. Shorter implants did not fail more than longer ones. The cumulative success rate was 99.40%. The predictable use of short implants supporting single crowns and small fixed partial dentures of 2-4 units supported by two to three implants permitted (1) restricting the need for sophisticated and expensive presurgical procedures aimed to determine precisely the available bone height by computerized radiographic methods, (2) the placement of prosthetically driven restoration instead os surgically driven ones, (3) reducing the indications span for complex invasive procedures like sinus lift and bon grafting procedures, (4) facilitating the surgery, without attempting to place the longest implant and (5) avoiding the occurrence of sensation disturbance. The safe use of short implants in a private practice should make implant therapy simpler and accessible to a higher number of patients and practitioners.

Short dental implants: a systematic review.

Annibali S, Cristalli MP, Dell'Aquila D, Bignozzi I, La Monaca G, Pilloni A.


Abstract

Growing evidence has suggested the utility of short dental implants for oral reconstructive procedures in clinical situations of limited vertical bone height. The aim of this review was to systematically evaluate clinical studies of implants < 10 mm in length, to determine short implant-supported prosthesis success in the atrophic jaw. Implant survival, incidence of biological and biomechanical complications, and radiographic peri-implant marginal bone loss were evaluated. Screening of eligible studies, quality assessment, and data extraction were conducted by two reviewers independently. Meta-analyses were performed by the pooling of survival data by implant surface, surgical technique, implant location, type of edentulism, and prosthetic restoration. Two randomized controlled trials and 14 observational
Studies were selected and analyzed for data extraction. In total, 6193 short-implants were investigated from 3848 participants. The observational period was 3.2 ± 1.7 yrs (mean ± SD). The cumulative survival rate (CSR) was 99.1% (95%CI: 98.8-99.4). The biological success rate was 98.8% (95%CI: 97.8-99.8), and the biomechanical success rate was 99.9% (95%CI: 99.4-100.0). A higher CSR was reported for rough-surfaced implants. 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 scientific evidence is needed for the long term.

**Failure rates of short (≤ 10 mm) dental implants and factors influencing their failure: a systematic review.**

Sun HL, Huang C, Wu YR, Shi B.


**Abstract**

**PURPOSE:**

The aim of this study was to evaluate the long-term failure rates of short dental implants (≤ 10 mm) and to analyze the influence of various factors on implant failure.

**MATERIALS AND METHODS:**

The PubMed and Cochrane Library databases were consulted for follow-up studies published between the years 1980 and 2009. For those studies that met the inclusion and exclusion criteria, data concerning the number of implants (≤ 10 mm) placed and lost and any related risk factors were gathered in tables and subjected to analysis. Univariate and multivariate analyses were performed.

**RESULTS:**

The heterogeneity and low quality of the included studies made meta-analysis impossible. A total of 35 human studies fulfilled the criteria. The studies included 14,722 implants, of which 659 failed. The total failure rate was 4.5%. The failure rates of implants with lengths of 6, 7, 7.5, 8, 8.5, 9, and 10 mm were 4.1%, 5.9%, 0%, 2.5%, 3.2%, 0.6%, and 6.5%, respectively. A majority (57.9%) of failures occurred before prosthesis connection. There was no statistically significant difference between the failure rates of short dental implants and standard implants or between those placed in a single stage and those placed in two stages (multivariate analysis). There was a tendency toward higher failure rates for the maxilla and for dental implants with a machined surface compared with the mandible and dental implants with a rough surface, respectively.

**CONCLUSIONS:**

Among the risk factors examined, most failures of short implants can be attributed to poor bone quality in the maxilla and a machined surface. Although short implants in atrophied jaws can achieve similar long-term prognoses as standard dental implants with a reasonable prosthetic design according to this review, stronger evidence is essential to confirm this finding.
Comparative evaluation of implant designs: influence of diameter, length, and taper on strains in the alveolar crest. A three-dimensional finite-element analysis.

Petrie CS, Williams JL.


Abstract

OBJECTIVES:
Our aim was to analyze and compare systematically the relative and interactive effects of implant diameter, length, and taper on calculated crestal bone strains.

MATERIAL AND METHODS:
Three-dimensional finite-element models were created of a 20-mm premolar section of the mandible with a single endosseous implant embedded in high- or low-density cancellous bone. Oblique (200-N vertical and 40-N horizontal) occlusal loading was applied. Cortical and cancellous bone were modeled as transversely isotropic and linearly elastic. Perfect bonding was assumed at all interfaces. A two-level factorial statistical design was used to determine the main and interactive effects of four implant design variables on maximum shear strains in the crestal alveolar bone: diameter, length of tapered segment, length of untapered segment, and taper. Implant diameter ranged from 3.5 to 6 mm, total implant length from 5.75 to 23.5 mm, and taper from 0 to 14 degrees, resulting in 16 implant designs.

RESULTS:
Increasing implant diameter resulted in as much as a 3.5-fold reduction in crestal strain, increasing length caused as much as a 1.65-fold reduction, whereas taper increased crestal strain, especially in narrow and short implants, where it increased 1.65-fold. Diameter, length, and taper have to be considered together because of their interactive effects on crestal bone strain.

CONCLUSION:
If the objective is to minimize peri-implant strain in the crestal alveolar bone, a wide and relatively long, untapered implant appears to be the most favorable choice. Narrow, short implants with taper in the crestal region should be avoided, especially in low-density bone.
The use of short, wide implants in posterior areas with reduced bone height: a retrospective investigation.

Griffin TJ, Cheung WS.

J Prosthet Dent. 2004 Aug;92(2):139-44.

Abstract

STATEMENT OF PROBLEM:

Reduced bone height frequently presents a challenge for implant-assisted tooth replacement in partially edentulous patients.

PURPOSE:

This retrospective study evaluated the success rate of short, wide hydroxyapatite (HA)-coated implants placed in mandibular and maxillary molar areas with reduced bone height.

MATERIAL AND METHODS:

A total of 168 HA-coated implants (6-mm diameter x 8-mm length) were placed in 167 patients in a private-practice setting. A minimal 6-mm workable ridge height and 8-mm ridge width was available in all situations. Patients were referred back to 1 of 7 referring restorative dentists for restoration of the implants. No attempt was made to standardize the restoration of the implants except to avoid working and nonworking contacts in lateral excursions. Implant success was evaluated according to the following criteria: (1) absence of complaints, (2) absence of recurring peri-implant infection or suppuration, (3) absence of perceptible implant mobility, and (4) absence of radiolucencies at implant-bone junction. The data were analyzed with descriptive statistics.

RESULTS:

Fifty-four (32.1%), 35 (20.8%), 36 (21.4%), and 42 (25.0%) implants replaced maxillary first and second and mandibular first and second molars, respectively. There were 128 implant-supported single crowns. Thirty-eight implants served as abutments for fixed partial dentures connected to other implants of various sizes. Two implants were involved in cantilevered fixed partial dentures. Patients were followed for up to 68 months (mean=34.9 months) after loading of implants. The overall cumulative success rate was found to be 100%.

CONCLUSIONS:

For residual ridges with minimal height but adequate width, the use of short, wide HA-coated implants may offer a simple and predictable treatment alternative in posterior areas.
Impact of implant length and diameter on survival rates.

Renouard F, Nisand D.


Abstract

INTRODUCTION:

Despite the high success rates of endosseous oral implants, restrictions have been advocated to their placement with regard to the bone available in height and volume. The use of short or nonstandard-diameter implants could be one way to overcome this limitation.

MATERIAL AND METHODS:

In order to explore the relationship between implant survival rates and their length and diameter, a Medline and a hand search was conducted covering the period 1990-2005. Papers were included which reported: (1) relevant data on implant length and diameter, (2) implant survival rates; either clearly indicated or calculable from data in the paper, (3) clearly defined criteria for implant failure, and in which (4) implants were placed in healed sites and (5) studies were in human subjects.

RESULTS:

A total of 53 human studies fulfilled the inclusion criteria. Concerning implant length, a relatively high number of published studies (12) indicated an increased failure rate with short implants which was associated with operators' learning curves, a routine surgical preparation (independent of the bone density), the use of machined-surfaced implants, and the placement in sites with poor bone density. Recent publications (22) reporting an adapted surgical preparation and the use of textured-surfaced implants have indicated survival rates of short implants comparable with those obtained with longer ones. Considering implant diameter, a few publications on wide-diameter implants have reported an increased failure rate, which was mainly associated with the operators' learning curves, poor bone density, implant design and site preparation, and the use of a wide implant when primary stability had not been achieved with a standard-diameter implant. More recent publications with an adapted surgical preparation, new implant designs and adequate indications have demonstrated that implant survival rate and diameter have no relationship.

DISCUSSION:

When surgical preparation is related to bone density, textured-surfaced implants are employed, operators' surgical skills are developed, and indications for implant treatment duly considered, the survival rates for short and for wide-diameter implants has been found to be comparable with those obtained with longer implants and those of a standard diameter. The use of a short or wide implant may be considered in sites thought unfavourable for implant success, such as those associated with bone resorption or previous injury and trauma. While in these situations implant failure rates may be increased, outcomes should be compared with those associated with advanced surgical procedure such as bone grafting, sinus lifting, and the transposition of the alveolar nerve.
Avoiding osseous grafting in the atrophic posterior mandible for implant-supported fixed partial dentures: a report of 2 cases.

Flanagan D.


Abstract

Bone atrophy occurs after tooth extraction in the posterior mandible, placing the mandibular canal and its neural, arterial, and venous contents closer to the osseous facial aspect and the coronal crest. This proximity places the structure in danger of damage when dental implants are surgically placed to support fixed or removable prostheses. Several options are available to treat these areas for implant-supported fixed and removable complete or partial dentures. Osseous grafting and ridge expansion are surgical options that enable acceptance of standard sized dental implants but have serious morbidities. Additionally, vertical osseous augmentation is not predictable at this time. Narrow diameter dental implants can be placed to avoid the mandibular canal, but some bone volume situations preclude this. Very wide and very short (6.5 × 5 mm) dental implants may be placed at an angle in atrophic sites to successfully support fixed partial dentures. An anterior guidance occlusal scheme may be used in maxillary dentate patients or group function in maxillary complete denture patients. A 100 micron occlusal relief in fixed partial dentures in dentate patients may be required to account for natural tooth intrusion and to prevent occlusal overload of the implant-supported partial denture.

Influence of variations in implant diameters: a 3- to 5-year retrospective clinical report.

Ivanoff CJ, Gröndahl K, Sennerby L, Bergström C, Lekholm U.


Abstract

Sixty-seven patients ranging in age from 16 to 86 years were included in this 3- to 5-year retrospective report focusing on implant survival and marginal bone remodeling in relation to implant diameter. A total of 299 Brånemark implants (3.75-mm diameter: 141; 4.0-mm diameter: 61; 5.0-mm diameter: 97) were placed in 16 completely and 51 partially edentulous arches. Seven of the 141 implants in the 3.75-mm-diameter group failed (5%). The corresponding value for the 4.0-mm-wide implants was 2 of 61 (3%). The highest failure rate, 18% (17/97), was seen for the 5.0-mm-diameter implants. The least favorable cumulative survival rates were seen in mandibles after 5 years and involving 4.0-mm- and 5.0-mm-diameter implants (84.8% and 73.0%, respectively). The marginal bone loss was generally low over the 5-year period. When the data were evaluated by the Cox regression analysis, a relationship was found between implant failure and implant diameter (P < .05), with a higher failure rate for the 5.0-mm-diameter implant. However, no relationship could be seen between implant failure and jaw type, or bone quality and quantity (P > .05). Neither was any relationship seen between marginal bone loss and bone quality and quantity, implant diameter, or jaw type when tested by multiple linear regression analysis (P > .05). A learning
curve, poor bone quality, and changed implant design were suggested as possible reasons for the less positive outcome seen for the 5.0-mm-diameter implant. The fact that this implant was often used as a rescue implant when the standard ones were not considered suitable or did not reach initial stability was another plausible explanation.

**Peri-implant biomechanical responses to standard, short-wide and mini implants supporting single crowns under axial and off-axial loading (An In-Vitro study).**

Kheiralla LS, Kheiralla LS, Younis JF.


**Abstract**

Abstract This study compared the biomechanical responses of three single crowns supported by three different implants under axial and off-axial loading. A standard implant; 3.75mm diameter, 13mm length, a mini implant; 3mm diameter, 13mm length, and a short-wide implant; 5.7mm diameter, 8mm length, were embedded in epoxy resin by the aid of a surveyor to ensure their parallelism. Each implant supported a full metal crown made of Ni-Cr alloy with standardized dimensions. Strain gauges and FEA were used to measure the strain induced under axial and off-axial functional loads of 300N. Results showed that; mini implants recorded the highest microstrains, under both axial and off-axial loading. All implants showed a considerable increase in strain values under off-axial loading. Standard and Short-wide implants proved to be preferable in supporting crowns; as standard implant showed the lowest strains under axial and off-axial loading using FEA simulation, while short-wide implant showed the lowest strains under non-axial loading using strain gauge analysis.

**Biomechanical finite element analysis of small diameter and short dental implant.**

Hasan I, Heinemann F, Aitlahrach M, Bouraue C.


**Abstract**

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.