Effects of implant thread geometry on percentage of osseointegration and resistance to reverse torque in the tibia of rabbits.


Abstract

BACKGROUND:

Dental implant thread geometry has been proposed as a potential factor affecting implant stability and the percentage of osseointegration. Therefore, the aim of this prospective, randomized, parallel arm study was to evaluate the effects of dental implant thread design on the quality and percent of osseointegration and resistance to reverse torque in the tibia of rabbits.

METHODS:

Seventy-two custom-made, screw-shaped, commercially pure titanium implants (3.25 mm diameter x 7 mm length) were placed in the tibiae of 12 white New Zealand rabbits. Each tibia received three implants of varying thread shapes: one with a V-shaped, one with a reverse buttress, and one with a square thread design. The rabbits were sacrificed following an uneventful healing period of 12 weeks. Implants in the right tibiae underwent histologic and histomorphometric assessments of the bone-to-implant contact (BIC) and the radiographic density of surrounding bone, while implants in the left tibiae were used for reverse-torque testing. Differences between the three thread designs were examined using analysis of variance (ANOVA).

RESULTS:

Data showed that the square thread design implants had significantly more BIC and greater reverse-torque measurements compared to the V-shaped and reverse buttress thread designs, while no differences were found in radiographic bone density assessments.

CONCLUSION:

These results indicate that the square thread design may be more effective for use in endosseous dental implant systems.
Factors influencing resonance frequency analysis assessed by Osstell mentor during implant tissue integration: I. Instrument positioning, bone structure, implant length.

Sim CP, Lang NP.


Abstract

AIM:

To monitor longitudinally the development of implant stability of SLA Straumann tissue-level implants using resonance frequency analysis (RFA) and to determine the influence of instrument positioning, bone structure and implant length on the assessment of RFA.

MATERIAL AND METHODS:

Thirty-two healthy adult patients received either 8 mm, v4.1 mm Straumann Standard Plus tissue-level implants (n=16: Group A) or 10 mm, v4.1 mm Straumann Standard Plus tissue-level implants (n=16: Group B). During healing, RFA was performed on Weeks 0, 1, 2, 3, 4, 5, 6, 8 and 12. The implants were restored after 10 weeks (impression taking) and 12 weeks. In addition, probing depth, presence of plaque and bleeding on probing were assessed. Implant stability quotient (ISQ) values of Groups A and B were compared using unpaired t-tests and longitudinally applying paired t-tests between Week 0 and the subsequent time points.

RESULTS:

Positioning of the Osstell mentor device did not affect the ISQ values. Generally, ISQ values increased continuously during healing from a mean of 65.1 (SD 16.97) to 74.7 (SD 5.17) (significantly from Week 0 to Weeks 6, 8 and 12). Lower bone density (Type III or IV) resulted in significantly lower ISQ values up to Week 8. Implant length affected the increase in ISQ values over time. While no significant increase was observed with 10 mm implants, ISQ values of 8 mm implants increased significantly from Week 0 to Weeks 6, 8 and 12.

CONCLUSIONS:

Using Osstell mentor, ISQ values are reproducible irrespective of instrument positioning. ISQ values are affected by the bone structure and implant length. Hence, no predictive values can be attributed to implant stability.

Factors influencing resonance frequency analysis assessed by Osstell mentor during implant tissue integration: II. Implant surface modifications and implant diameter.

Han J, Lulic M, Lang NP.


Abstract
OBJECTIVES:
To monitor the development of the stability of Straumann tissue-level implants during the early phases of healing by resonance frequency analysis (RFA) and to determine the influence of implant surface modification and diameter.

MATERIAL AND METHODS:
A total of twenty-five 10 mm length implants including 12 SLA RN v4.1 mm implants, eight SLActive RN v4.1 mm implants and five SLA WN v4.8 mm implants were placed. Implant stability quotient (ISQ) values were determined with Osstell mentor at baseline, 4 days, 1, 2, 3, 4, 6, 8 and 12 weeks post-surgery. ISQ values were compared between implant types using unpaired t-tests and longitudinally within implant types using paired t-tests.

RESULTS:
During healing, ISQ decreased by 3-4 values after installation and reached the lowest values at 3 weeks. Following this, the ISQ values increased steadily for all implants and up to 12 weeks. No significant differences were noted over time. The longitudinal changes in the ISQ values showed the same patterns for SLA implants, SLActive implants and WB implants. At placement, the mean ISQ values were 72.6, 75.7 and 74.4, respectively. The mean lowest ISQ values, recorded at 3 weeks, were 69.9, 71.4 and 69.8, respectively. At 12 weeks, the mean ISQ values were 76.5, 78.8 and 77.8, respectively. The mean ISQ values at all observation periods did not differ significantly among the various types. Single ISQ values ranged from 55 to 84 during the entire healing period. Pocket probing depths of the implants ranged from 1 to 3 mm and bleeding on probing from 0 to 2 sites/implant post-surgically.

CONCLUSIONS:
All ISQ values indicated the stability of Straumann implants over a 12-week healing period. All implants showed a slight decrease after installation, with the lowest ISQ values being reached at 3 weeks. ISQ values were restored 8 weeks post-surgically. It is recommended to monitor implant stability by RFA at 3 and 8 weeks post-surgically. However, neither implant surface modifications (SLActive) nor implant diameter were revealed by RFA.

Dental implant design and its relationship to long-term implant success.
Steigenga JT, al-Shammari KF, Nociti FH, Misch CE, Wang HL.

Abstract
The purpose of this review is to evaluate the effects of the biomechanical aspects of dental implant design on the quality and strength of osseointegration, the bone-implant interface, and their relationships to the long-term success of dental implants. The engineering design of implants is based on many interrelated factors, including the geometry of the implant, mechanical properties, and the initial and long-term stability of the implant-tissue interface. There is no one "optimal" design criterion. However, implants can be engineered to maximize strength, interfacial stability, and load transfer by using different materials, surfaces, and thread designs. Limited information is currently available in addressing how implant thread
design influences the overall implant success. Therefore, this article reviews and discusses design elements of various dental implant systems currently in use as they affect the quality of osseointegration and their relationship to overall long-term success patterns.

The influence of implant diameter and length on stress distribution of osseointegrated implants related to crestal bone geometry: a three-dimensional finite element analysis.

Baggi L, Cappelloni I, Di Girolamo M, Maceri F, Vairo G.


Abstract

STATEMENT OF PROBLEM:

Load transfer mechanisms and possible failure of osseointegrated implants are affected by implant shape, geometrical and mechanical properties of the site of placement, as well as crestal bone resorption. Suitable estimation of such effects allows for correct design of implant features.

PURPOSE:

The purpose of this study was to analyze the influence of implant diameter and length on stress distribution and to analyze overload risk of clinically evidenced crestal bone loss at the implant neck in mandibular and maxillary molar periimplant regions.

MATERIAL AND METHODS:

Stress-based performances of 5 commercially available implants (2 ITI, 2 Nobel Biocare, and 1 Ankylos implant; diameters of 3.3 mm to 4.5 mm, bone-implant interface lengths of 7.5 mm to 12 mm) were analyzed by linearly elastic 3-dimensional finite element simulations, under a static load (lateral component: 100 N; vertical intrusive component: 250 N). Numerical models of maxillary and mandibular molar bone segments were generated from computed tomography images, and local stress measures were introduced to allow for the assessment of bone overload risk. Different crestal bone geometries were also modelled. Type II bone quality was approximated, and complete osseous integration was assumed.

RESULTS:

Maximum stress areas were numerically located at the implant neck, and possible overloading could occur in compression in compact bone (due to lateral components of the occlusal load) and in tension at the interface between cortical and trabecular bone (due to vertical intrusive loading components). Stress values and concentration areas decreased for cortical bone when implant diameter increased, whereas more effective stress distributions for cancellous bone were experienced with increasing implant length. For implants with comparable diameter and length, compressive stress values at cortical bone were reduced when low crestal bone loss was considered. Finally, dissimilar stress-based performances were exhibited for mandibular and maxillary placements, resulting in higher compressive stress in maxillary situations.
CONCLUSIONS:

Implant designs, crestal bone geometry, and site of placement affect load transmission mechanisms. Due to the low crestal bone resorption documented by clinical evidence, the Ankylos implant based on the platform switching concept and subcrestal positioning demonstrated better stress-based performance and lower risk of bone overload than the other implant systems evaluated.

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.
Methods used to assess implant stability: current status.

Atsumi M, Park SH, Wang HL.


Abstract

Successful osseointegration is a prerequisite for functional dental implants. Continuous monitoring in an objective and quantitative manner is important to determine the status of implant stability. Historically, the gold standard method used to evaluate degree of osseointegration was microscopic or histologic analysis. However, due to the invasiveness of this method and related ethical issues, various other methods of analysis have been proposed: radiographs, cutting torque resistance, reverse torque, modal analysis, and resonance frequency analysis. This review focuses on the methods currently available for the evaluation of implant stability. (More than 50 references.)

Validity and clinical significance of biomechanical testing of implant/bone interface.

Aparicio C, Lang NP, Rangert B.


Abstract

PURPOSE:

The aim of this paper was to review the clinical literature on the Resonance frequency analysis (RFA) and Periotest techniques in order to assess the validity and prognostic value of each technique to detect implants at risk for failure.

MATERIAL AND METHODS:

A search was made using the PubMed database to find clinical studies using the RFA and/or Periotest techniques.

RESULTS:

A limited number of clinical reports were found. No randomized-controlled clinical trials or prospective cohort studies could be found for validity testing of the techniques. Consequently, only a narrative review was prepared to cover general aspects of the techniques, factors influencing measurements and the clinical relevance of the techniques.

CONCLUSIONS:

Factors such as bone density, upper or lower jaw, abutment length and supracrestal implant length seem to influence both RFA and Periotest measurements. Data suggest that high RFA and low Periotest values indicate successfully integrated implants and that low/decreasing RFA and high/increasing Periotest values may be signs of ongoing disintegration and/or marginal bone loss. However, single readings using any of the techniques are of limited clinical value. The prognostic value of the RFA and Periotest
techniques in predicting loss of implant stability has yet to be established in prospective clinical studies.

The influence of implant type, material, coating, diameter, and length on periotest values at second-stage surgery: DICRG interim report no. 4. Dental Implant Clinical Research Group.

Ochi S, Morris HF, Winkler S.

Implant Dent. 1994 Fall;3(3):159-62.

Abstract

Many of the presently used methods of evaluating osseointegration at second-stage surgery are highly subjective. The Periotest is claimed to offer a more objective means to assess osseointegration by means of microcomputer-controlled percussion. In 1991 the Dental Implant Clinical Research Group initiated a long-term clinical study in cooperation with the Department of Veterans Affairs to investigate the influence of implant design, application, and site of placement on clinical performance and crestal bone height. As part of this investigation, the Periotest values for 1,565 root form implants were determined at second-stage surgery and correlated with type, material, coating, diameter, and length. Hydroxyapatite-coated implants and increased implant diameter and length produced Periotest values that indicated a greater extent of stability as compared with noncoated implants with shorter diameters and lengths. Hydroxyapatite-coated cylinder-type implants yielded the most favorable Periotest readings. Not only does the Periotest have the potential of being a valuable instrument for assessing implant mobility at second-stage surgery, but it also appears to have the capability of determining slight differences in the implant-bone complex.

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.

Influence of implant taper on the primary and secondary stability of osseointegrated titanium implants.

O’Sullivan D, Sennerby L, Meredith N.


Abstract

OBJECTIVES:

The study presented was designed to analyse the mechanical performance and the primary and secondary stability characteristics of endosseous titanium implants with 1 degree (EXP1) and 2 degrees (EXP2) of taper when compared with the standard Brånemark design (Nobel Biocare AB, Gothenburg, Sweden).

MATERIALS AND METHODS:

One pair of 10 mm EXP1 and control implants were placed in the femoral condyles of six rabbits. Paired 6 mm EXP1 and control implants and 6 mm EXP2 and control implants were placed in the tibial metaphysis. The control implants used were 4 mm diameter standard
Brånemark implants, the same length as the test implants. At placement, insertion torque (IT) and resonance frequency analysis (RFA) measurements were performed. Six weeks postoperatively when the animals were killed, RFA and removal torque (RT) measurements were made.

RESULTS:

At placement, significantly higher IT was needed to insert the EXP implants compared with the controls. RFA values were significantly higher for EXP1 implants placed in the tibia but not in the femur. In pooling data from the femur and tibia there was a significant difference. The EXP2 implants failed to insert fully and demonstrated a lower RFA value than may have been expected due to the exposed threads, although this difference was not statistically significant.

CONCLUSIONS:

The results from the present study showed that 1 degrees of taper results in a better primary stability compared with the standard Brånemark design. There was no evidence that the tapered design caused negative bone tissue reactions. All the implants gained in stability during the healing period.

Assessment of implant stability as a prognostic determinant.

Meredith N.


PURPOSE:

This paper aims to establish the parameters necessary to monitor successful implant placement and osseointegration.

RESULTS AND DISCUSSION:

Implant stability is considered to play a major role in the success of osseointegration. Primary implant stability at placement is a mechanical phenomenon that is related to the local bone quality and quantity, the type of implant and placement technique used. Secondary implant stability is the increase in stability attributable to bone formation and remodeling at the implant/tissue interface and in the surrounding bone. Techniques for measuring implant stability and osseointegration, including the clinical measurement of cutting resistance during implant placement and removal torque following osseointegration, are discussed. Nondestructive test methods, including impact-based techniques such as the Periotest and the Dental Fine Tester, are also discussed. An alternative method, resonance frequency analysis, is described in detail.

CONCLUSION:

It is clear that stability both at placement and during function is an important criterion for the success of dental implants. Quantitative methods, including resonance frequency analysis, can yield valuable information.
Implant stability measurement of delayed and immediately loaded implants during healing.


Abstract

The purpose of the present study was (1) to measure the primary stability of ITI implants placed in both jaws and determine the factors that affect the implant stability quotient (ISQ) determined by the resonance frequency method and (2) to monitor implant stability during the first 3 months of healing and evaluate any difference between immediately loaded (IL) implants and standard delayed loaded (DL) implants. The IL and DL groups consisted of 18 patients/63 implants and 18 patients/43 implants. IL implants were loaded after 2 days; DL implants were left to heal according to the one-stage procedure. The ISQ was recorded with an Osstell apparatus (Integration Diagnostics AB, Gothenburg, Sweden) at implant placement, after 1, 2, 4, 6, 8, 10 and 12 weeks. Primary stability was affected by the jaw and the bone type. The ISQ was higher in the mandible (59.8+/−6.7) than the maxilla (55.0+/−6.8). The ISQ was significantly higher in type I bone (62.8+/−7.2) than in type III bone (56.0+/−7.8). The implant position, implant length, implant diameter and implant deepening (esthetic plus implants) did not affect primary stability. After 3 months, the gain in stability was higher in the mandible than in the maxilla. The influence of bone type was leveled off and bone quality did not affect implant stability. The resonance-frequency analysis method did not reveal any difference in implant stability between the IL and DL implants over the healing period. Implant stability remained constant or increased slightly during the first 4-6 weeks and then increased more markedly. One DL and IL implant failed; both were 8 mm long placed in type III bone. At the 1-year control, the survival rate of the IL and the DL implants was 98.4% and 97.7%, respectively. This study showed no difference in implant stability between the IL and DL procedures over the first 3 months. IL short-span bridges placed in the posterior region and full arch rehabilitation of the maxilla with ITI sandblasted-and-etched implants were highly predictable.

Implant stability in relation to osseointegration: an experimental study in the Labrador dog.

Abrahamsson I, Linder E, Lang NP.


Abstract

OBJECTIVE:

Resonance frequency analysis (RFA) is supposed to determine implant stability. The relation between RFA and the degree of bone-to-implant contact (BIC), however, is unclear. The objective of the present experiment was to evaluate RFA values in relation to osseointegration.
MATERIAL AND METHODS:

In 20 Labrador dogs, all mandibular premolars were extracted bilaterally. After 3 months, four transmucosal screw-shaped experimental implants were placed in each mandibular premolar region. The implants (12 mm length, slashed circle 4.1mm, insertion depth 9 mm) were either SLA surface or turned surface implants. The animals were divided into four groups (five dogs in each group) to study healing following implant installation at 2 h, 4 days, 1, 2, 4, 6, 8 and 12 weeks. Two experimental implants of each type were installed in each edentulous premolar region. A plaque control program was initiated 2 weeks after each implant installation. RFA assessments were performed at the time of implant installation, at one to three occasions during the monitoring period and at the termination of the experiment. At the end of the experiment, the dogs were sacrificed and each implant site was dissected and processed for histological analysis. The results of the histological analysis, i.e. marginal bone level, degree of osseointegration (BIC%) and bone density, were compared with the corresponding Implant Stability Quotient (ISQ) values of the RFA assessment.

RESULTS:

No correlations between histological parameters of osseointegration and ISQ values could be identified. Marginal bone level changes, differences in BIC% and bone density were not reflected in the RFA at any time-point during the 12-week monitoring period.

CONCLUSION:

The value of RFA to predict implant stability over time and to determine at which time-point an implant may be exposed to functional load has to be questioned.

Relationship between cortical bone thickness or computerized tomography-derived bone density values and implant stability.

Merheb J, Van Assche N, Coucke W, Jacobs R, Naert I, Quirynen M.


Abstract

AIMS:

To explore the relationship between primary implant stability and different parameters related to implant or bone properties.

MATERIALS AND METHODS:

Twenty-four patients received a total of 136 Straumann SLActive implants. Resonance frequency analysis (RFA) was performed at implant placement, and RFA and Periotest (PTV) were scored at loading. Bone density [Hounsfield (HU) scores] and coronal cortical thickness at osteotomy sites were measured from pre-operative computerized tomography scans.

RESULTS:
Implant length, diameter or the presence of bony dehiscence did not have a significant effect on the mean RFA scores at implant insertion. Significant linear relations were found between RFA or PTV scores and HU values (P<0.05), or cortical bone thickness (P<0.05), both at insertion as well as at loading.

**CONCLUSION:**

RFA and PTV scores can be predicted based on implant and especially bone related factors.

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**Validation of implant stability: A measure of implant permanence.**

Mall N, Dhanasekar B, Aparna IN.


**Abstract**

Implant stability is a requisite characteristic of osseointegration. Without it, long-term success cannot be achieved. Continuous monitoring in a quantitative and objective manner is important to determine the status of implant stability. Measurement of implant stability is a valuable tool for making decisions pertaining to treatment protocol and also improves dentist-patient communication. Owing to the invasive nature of histological analysis, various other methods have been proposed like radiographs, cutting torque resistance, reverse torque, modal analysis, resonance frequency analysis and Implant®. This review focuses on objectives and various methods to evaluate implant stability.

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**Bone quality, quantity and metabolism in terms of dental implantation.**

Fanghanel J, Gedrange T, Proff P.


**Abstract**

The present paper provides an introduction to regular bone structure in the face area which is considered a precondition of successful implantation. The specific properties of the jaw bones have to be observed in this context. Bone is the largest calcium storage, forms part of the supporting tissue and displays distinctive plasticity and adaptability. Thus, an adequate, differentiated composition and metabolism are required. The bone matrix consists of organic and inorganic structures. The cells, osteoblasts, osteoclasts and osteocytes are responsible for bone formation, resorption and metabolism and, thus, for remodeling processes (formation and resorption) which permanently occur in bone tissue. Periosteum and endosteum form a functional unit with bone tissue itself and exercise protective, nutritive and growth functions.