Influence of undersized Implant site on Implant stability and Osseointegration.

AUTHORS:

1. **Dr. Raj Gaurav Rohatgi:** Reader, Department of oral & maxillofacial surgery, Institute of dental sciences, Bareilly International University, Bareilly (U.P)E mail: rajrohatgi@gmail.com
2. **Dr. Suneel G Patil**: Associate Professor, Department of Dentistry, Karnataka institute of medical sciences, Hubli, Karnataka.
3. **Dr. Fahiem Mohammad Mohammad El-Shamy**, lecturer in dental biomaterials, Department of dental biomaterials, Faculty of Dentistry, Mansoura University, Egypt, ZIP/Postal Code:45142, Email: fahiemm@yahoo.com
4. **Dr. Kaushik Chakraborty** MDS, BDS, ASSOCIATE PROFESSOR Department of Pedodontics and Preventive Dentistry, North Bengal Dental College and Hospital, Sushrutanagar e mail: drpedo1974@gmail.com
5. **Dr. Anand krishnan**: Senior Lecturer, Faculty of Dentistry, Lincoln University, Malaysia.
6. **Dr Swamy M C L,** Reader, Dept of Oral Medicine and Radiology, College of Dental sciences, Davangere. Email- swamymcl@yahoo.co.in

Corresponding Author:

Dr. Raj Gaurav Rohatgi: Reader, Department of oral & maxillofacial surgery, Institute of dental sciences, Bareilly International University, Bareilly (U.P) E mail: rajrohatgi@gmail.com

Abstract:

Objective: The objectives of this study was to assess the instrument design in comparison to the implant design, compare the initial implant stability obtained using four different osteotomy techniques in low-density synthetic bone, and determine a potential correlation between the insertion torque and initial stability quotient (ISQ).

Methodology: According to the osteotomy method employed (n = 10 implants per group), four groups were established: group G1, osteotomy using the suggested drilling sequence; group G2, osteotomy using an undersized compactor drill; group G3, osteotomy using an undersized drill; and group G4, osteotomy using universal osseodensification drills. There were two polyurethane blocks used: block 1, with a medullary portion of 10 pounds per cubic foot (PCF 10), and block 2,

with a medullary portion of 15 pounds per cubic foot (PCF 15), and a 2 mm cortical section of 40

pounds per cubic foot (PCF 40). 11 mm in length and 4 mm in diameter tapered implants were employed. Both the ISQ and the insertion torque (IT) were measured.

Results: Depending on the method employed for the osteotomy in the two synthetic bone models, differences between the four groups were discovered for IT and ISQ values (p 0.0001). In comparison to block 2, all groups displayed decreased initial stability values in block 1.

Conclusion: When compared to beds prepared with universal drills and utilising the drilling sequence prescribed by the manufacturer, undersized osteotomies performed with instruments made specifically for the implant body considerably boosted the initial stability values.

Introduction:

Dental implants, one of the most significant developments in dentistry, have completely changed oral rehabilitation since their introduction. The placement of implants in regions with low bone density, however, has posed a significant problem for treatment predictability. Therefore, finding novel solutions for these circumstances has become a hot topic in implant dentistry, leading to the presentation of innovative micro- and macrogeometric implant designs[1–5]. Additionally, modifications to the surgical procedure and the kind of instrumentation used for implant installation have been proposed[6–8]. Currently, a bone extractor (drilling) is employed to create a surgical bed with a diameter that is comparable to that of the implant that is to be installed.Subinstrumentation, which aims to increase the bone-initial implant contact, and bone compaction by manual or rotary osteotomes, which aims to raise the bone density surrounding the implant, are two of the main procedures recommended for the installation of implants in low-density bone[9–12]. The proportion of bone-implant contact may decrease and the osseointegration process may be compromised by these treatments' inability to consistently increase initial stability[7, 13, 14].

Osteodensification is an osteotomy procedure that preserves the bone and enhances bone density by compacting the bone with instruments, resulting in the enlargement of the site and increasing its density, as first described by Huwais and Meyer[15]. By enhancing the bone-implant contact, initial installation torque, and primary stability even in difficult circumstances, this approach can increase the quality of the bone around implants. There have already been a number of preclinical[15–19] and clinical[20–21] investigations conducted that show the improvement of these biological variables in the peri-implant bone, which can increase the likelihood that treatments will be successful. However, some implant systems employ surgical tools that are identical in structure and operation to those created specifically for osseodensification.

The major goal of this study was to examine the first stability levels established by various instruments and/or methodologies suggested to improve the initial stability for osteotomy, as determined by the insertion torque and frequency analysis by resonance (RFA). Low-density polyurethane synthetic blocks were used to place implants inside them, replicating two different densities of bone. Additionally, measurements and analyses were done on the area of the implant body, both with and without threads, in relation to the body of the last instrument used for the conformation of the osteotomy in each group. Analysis was done on a potential relationship between insertion torque and ISQ.

Methodology:

Based on the osteotomy operation, four distinct groups were found in the current study:

Group G1 represents the standard osteotomy sequence recommended by the implant manufacturer for the 4.0 mm conical implant, consisting of a pilot drill, a 2.0 mm drill, a 3.5 mm conical drill, and finally a 4.0 mm conical drill;

Group G2 represents an osteotomy sequence using a compactor instrument, consisting of a pilot drill, a 2.0 mm drill, and a compactor drill withanticlockwise rotation.

Group G3: an undersized osteotomy sequence that uses a pilot drill, a 2.0 mm drill, and a 3.0 mm conical drill

Group 4: A pilot drill is followed by tapered universal drills with incremental diameters of 2.3 mm and 3.3 mm withanti-clockwise rotationfor osteotomy.

We used an implant surgical motor with a 20:1 contra-angle and a speed of 1100 rpmto complete all of the osteotomies.The American Society for Testing and Materials has approved and recognised polyurethane foam as a standard material for testing instruments and bone implants[22-23]. Polyurethane foam blocks of two different densities were used: block 1, with PCF ten for the medullary portion and PCF forty for the 1 mm cortical portion, and block two, with PCF fifteen for the medullary portion and PCF forty for the 2 mm cortical portion.

These polyurethane blocks (blocks 2 and 1 for bone types 3 and 4, respectively) were used to simulate poor bone density. The polyurethane blocks utilised had overall dimensions of 95 mm, 45 mm, and 35 mm.Following the osteotomies, 80 implants—20 samples in each group—were placed in the two blocks, yielding a total of 10 samples from each group in each block. All of the implants in use shared the following macrogeometric traits: Maestro implants (Implacil, So Paulo, Brazil) are 4 mm in diameter and 11 mm in length, with a Morse taper connection. These implants are conical in shape and have healing chambers and trapezoidal threads.The subsequent measurements were made:

1) the measurement of insertion torque (IT), with the maximum torque measured during the insertion of the implants in the synthetic blocks until the point at which the implant platform was at bone level;

2) the measurement of initial stability by RFA using the Osstell Mentor Device (Integration Diagnostic AB, Savadelen, Sweden), wherein immediately following the insertion of each implant, a Smart-peg was inserted.

For each sample, two measurements were made from various angles.The size of the total area calculated for the bodies of the tools used for the osteotomies in each group was compared to the size of the total area computed for the implant body without the threads and the size of the entire external area of the implant with the threads.

Statistical Analysis:
To ensure that the data were normal, the D'Agostino and Pearson omnibus normality test was used. To find significant differences between the results for several groups within the same bone block, one-way ANOVA was used. The data between the groups in the same bone block model were then statistically compared using the Bonferroni's multiple comparison test. The association between insertion torque and initial stability quotient in each suggested group was assessed using Pearson's correlation test. A p-value of<0.05 was considered for determining statistical significance.

Results:

Block 2 demonstrated a 134.3% higher average insertion torque and a 39.2% higher average ISQ compared to block 1 for all four groups within the same synthetic bone model. Additionally, the four groups showed statistically significant (p 0.0001) variations in insertion torque in both blocks. For the suggested groups in both blocks, the measured ISQ values for the implants showed varying values, with statistically significant differences (p 0.0001). In the suggested groups, there was no link found between the insertion torque and ISQ values. The analysis findings for each group in both synthetic bone blocks are displayed in Table 3.The implant body's area was calculated to be 159.9 mm^2 without the threads, and 175 mm^2 overall with the threads.
Table 1: Comparison of insertion torque values between the groups in the two synthetic bone blocks (Bonferroni's multiple comparison test)

Parameters	Block 1			Block 2		
	Mean difference	Confidence interval at 95%	p-value	Mean difference	Confidence interval at 95%	p-value
G1 vs G4	-2.50	-6.760 to 1.760	0.0241	-18.4	-25.28 to -11.52	0.0001*
G1 vs G3	-19.40	-23.66 to -15.14	0.0001	-26.9	-33.78 to -20.02	0.0001*
G1 vs G2	-14.90	-19.16 to - 10.64	0.0001	-25.4	-32.28 to - 18.52	0.0001*
G2 vs G4	12.40	8.140 to 16.66	0.0002	7.0	0.1235 to 13.88	0.0498*
G2 vs G3	-4.50	-8.76 to -0.2403	0.0532	-1.5	-8.376 to 5.376	0.8642
G3 vs G4	16.90	12.64 to 21.16	0.0002	8.5	1.624 to 15.38	0.0084*

Table 2: Comparative statistical evaluation of the ISQ scores for the four groups in each of the tested block models.

Parameters	Block 1			Block 2		
	Mean difference	Confidence interval at 95%	p-value	Mean difference	Confidence interval at 95%	p-value
G1 vs G4	0.05	-1.288 to 1.388	0.8414	-8.960	-12.09 to -5.835	0.0002*
G1 vs G3	-10.70	-12.04 to -9.362	0.0002	-15.34	-18.47 to -12.21	0.0002*
G1 vs G2	-9.100	-10.44 to	0.0002	-17.00	-20.13 to -	0.0002*

		-7.762			13.87	
G2 vs G4	9.150	7.812 to 10.49	0.0002	8.040	4.915 to 11.17	0.0021*
G2 vs G3	-1.600	-2.938 to -0.2622	0.0218	1.660	-1.465 to 4.785	0.2189
G3 vs G4	10.75	9.412 to 12.09	0.0002	6.380	3.255 to 9.505	0.0028*

Table 3: Pearson correlation Analysis

Parameters	Block 1		Block 2	
	Pearson correlation	p-value	Pearson correlation	p-value
G4	0.42	0.22	0.61	0.05
G3	0.23	0.51	-0.26	0.45
G2	0.14	0.68	0.02	0.93
G1	0.46	0.17	-0.12	0.73

Discussion:

In order to prepare the implant bed in low-density synthetic polyurethane bone blocks, four osteotomy techniques were compared. One used the recommended drill sequence for the implant design, and the other three used undersized sequences. Additionally, to assess the relationship between the area and the initial implant stability, the areas of the implant body, the implant body plus the external threads, and the pertinent instruments were calculated (IT and ISQ values).The obtained results revealed that even when using an undersized osteotomy, the initial implant stability (IT and ISQ values) in block 1 was quite low for all groups in comparison to that in block 2. Additionally, we confirmed that the design relationship between the parts had a substantial impact on the outcomes by comparing the calculated areas of each part employed (implant and instruments) to the initial stability data gathered.Installing implants in locations with poor bone density can make it difficult to get sufficient initial stability, which is thought to be a necessary requirement to get enough osseointegration[24–29]. The presence of implant micromovements immediately following insertion into the bone tissue is used to assess initial stability[30, 31]. According to the bulk of publications on the early stability of implants, insertion torque measurement and resonance frequency analysis are the most often employed methods for determining initial stability[32-34], therefore we selected these methods for our investigation.

The first clinical data regarding initial stability following implant implantation is the insertion torque. Using the drilling sequence suggested for osteotomy for the implant design employed makes it simple to achieve an appropriate initial implant stability with a high insertion torque in bone types 1 and 2, which exhibit high density[35].However, using the suggested drilling sequence suggested by the manufacturer, it was demonstrated to be more challenging to obtain adequate initial stability in bone types 3 and 4, which have low density, high values for insertion torque, and consequently, this finding supports our findings in the present study.With obvious underdimensioning in respect to the diameter of the implant to be implanted, various modifications to the bed preparation procedure utilised for implant insertion were tried. Undersized beds have been widely tested and reported in the literature[37–39], leading to solutions that are now thought of as universal for this use. However, our results showed values significantly lower than those shown for groups G2 and G3 (127.2% higher on average), where undersized instruments from the same manufacturer for the implant were used. This group (group G4) had the bed prepared using a universal system for osteotomy in low-density bone (block 1). These findings support those that Delgado-Ruiz and colleagues recently published.

When comparing the results from each block employed, block 2 displayed higher initial stability values than those discovered for block 1. Both the insertion torque and the ISQ increased by a combined 134.3%. These findings are in line with prior research that demonstrated that bone density[36, 39], and in particular the thickness of the cortical component[41, 42], directly affect the initial stability of the implant, irrespective of the implant's shape or the method used to prepare the bed. However, the implant's macrogeometry can also have a significant impact on the initial stability[43-45]. For this reason, the same implant model was used in our study for all suggested groups.

Our findings indicated that an important component to take into account is the implant design as compared to the instrument design employed for the osteotomy. In groups G2 and G3, where the instrument design took into account the design of the implant body, the greatest findings for initial stability were obtained for both synthetic bone densities evaluated. Although the relationship between the instrument's calculated area within the bone bed and the implant body with and without threads showed comparable values for groups G3 and G4, the IT and RFA results were significantly better for group G3, which led us to believe that the difference lay in the design of the parts' dimensions.

Conclusion:

We deduced from the data, and within the constraints of the current in vitro investigation, that undersized osteotomy should be carried out using an instrument made to the dimensions of the implant body in order to increase the initial stability values of the implants. In comparison to the stability obtained through preparation with undersized instruments that were designed for the implant model used, the initial stability of the implants was low when the implant bed was prepared with universal osseodensification instruments, especially in lower-density bone (PCF 10).

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