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Comparison of the primary stability achieved by using dental implants with variable thread designs when placed using different drilling techniques. An *in vitro* bone modular analysis

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ABSTRACT

Aim Missing teeth causes masticatory and esthetic insufficiency in the patient. Dental implants have been considered to be one of the best treatment modalities for tooth replacement. Implants can be placed using different drilling techniques. Implants integrate with the bone and therefore come closest to simulate the natural tooth. Once the implant is placed its primary stability can be measured. Primary stability is the stability of the implant immediately after it is placed into the bone. It is measured using smart pegs and a resonance frequency analysis (RFA)machine. The objective of designing this study was to compare and evaluate the primary stability of different implant systems when placed using three different drilling techniques.
Materials and methods A 16-inch bovine bone was chosen as sample. Six implant systems were chosen having three different macro geometries, namely: true taper, parallel walled taper and parallel walled designs. Five implants were taken from each of the implant system and placed into the bovine bone using three different drilling techniques, namely: conventional, under preparation and reverse drilling protocol. After each implant is placed, primary stability is measured using the corresponding smart pegs and RFA machine. All the values are tabulated and subjected to statistical analysis.
Results All implants were placed in the bovine bone and primary stability was measured. It was proven that the implants placed using reverse drilling technique have higher ISQ values compared to conventional and under preparation technique.
Conclusions The ISQ values were significantly higher in reverse drilling technique than in conventional and under preparation technique.

KEYWORDS Drilling techniques, Bovine bone, Primary stability, ISQ.

INTRODUCTION

Dental implants have emerged as one of the most preferred modalities for tooth replacement in the recent times (1). Implant therapy consists in the placement of a titanium implant into the endosseous bone (1). The success of implant therapy depends on the attainment of osseointegration (2). Osseointegration is the direct structural and functional connection between bone and the surface of an implant (2). Albrektsson et al., indicated six major parameters that play a key role in achieving osseointegration: implant material, surgical technique, implant surface, implant design, biomechanical factors and host factors(2).
Implant design parameters lay the foundation for properties like implant primary stability and ability to sustain loading during or after osseointegration. Implant design is divided into two major categories: micro design and macro design. Macro design includes implant body shape, thread and thread design, while micro design constitutes surface morphology, implant materials, and surface coating (3).
Implant thread design is another contributing factor to implant stability (4). Each thread design is proven to give a varying degree of apical and lateral compression to the adjacent bone, which will in turn produce a specific amount of osteocompression and primary stability (4).
Surgical technique of implant placement also plays a vital role in establishing osseointegration (5). If, during ostetomy preparation, drilling temperature exceeds 47°C for more than a minute, local osteonecrosis and impair osseointegration may happen(5). Various drilling protocols have been established for implant placement namely, conventional, under preparation or osseodensification techniques (6).
In conventional technique, a series of drills are used to expand the osteotomy according to the required dimension for implant placement (2). Literature recommends using a graded series of drill sizes rather than one single large drill (2). Each drill removes a designated amount of bone (2). Since prior drills have already removed a considerable

amount of bone, the larger diameter drills are required to cut minor amount of bone, resulting in lesser temperature increase and bone damage (2,5,6) In reverse drilling technique, apart from the pilot drill and the first drill, all other drills are rotated anticlockwise, with the last drill being one dimension smaller than the dimension of the implant (2,5,6). The usage of such final drill causes condensation of bone and optimization of bone density (2,5,6). This is a surgical technique used to enhance the primary stability of the implant. In case of poor bone quality, to enhance primary stability, a 10% undersized implant bed is prepared (2).

Primary stability is considered as achieved when there is no micromovement of the implant, after that it is completely seated in its position (2). This facilitates the mechanical interlocking of implant with bone tissue until secondary stability is achieved (2). Implant stability can be quantified as Implant Stability Quotient (ISQ), with values ranging from 1 to 100 (2). High ISQ values designate good implant stability (2). The ISQ value signifies the lateral stability of the implant, which is influenced by the rigidity of the connection between the bone and the implant surface (2).

Commonly, primary stability is assessed by two clinical parameters: insertion torque (IT) and resonance frequency quotient (RFA) (6). Insertion torque, is a measure of the rotational friction of the implant and is a purely mechanical factor, making it a good indicator to judge the primary stability (6). On the other hand, RFA is based on resonance frequency of the implant–bone complex analysis (6). It is measured by means of a transducer, that is directly inserted into the implant (6). RFA basically measures the stiffness and deflection of the implant in the bone.

FIG. 1 Bovine bone.

As mentioned earlier, primary stability of the implant is defined by implant macrogeometry. There was a need to understand if primary stability varied, when different drilling techniques were used. In order to clinically understand this, measuring techniques like RFA and IT were used.

This present study was designed to evaluate the difference in primary stability when implants of different macrogeometry were placed by different drilling techniques.

MATERIALS AND METHODS

A bovine femur bone of a male cow (Fig. 1) was procured from a local slaughter house, cut on the same day as the study and preserved in 10% formaldehyde solution. It

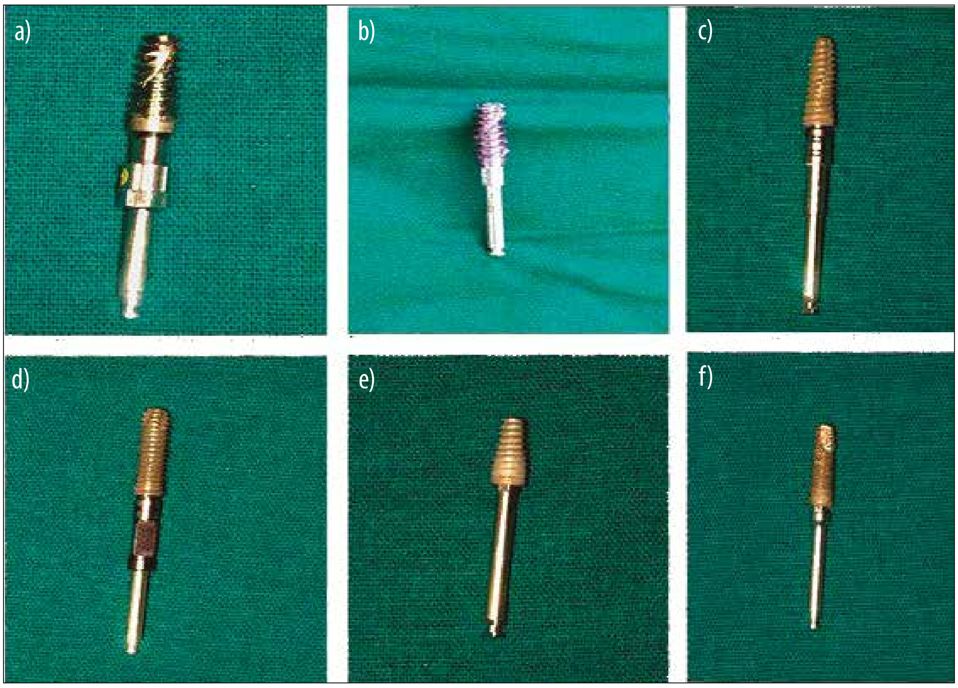


FIG. 2 From left to right: a) Nobel active implant, b) Straumann implant, c) Osstem implant, d) Dio implant, e) Bio3 implant and f) Zimmer implant.

was used as formalin and was diluted with water before using as a preservative. Ideally, it should be mixed at a ratio of nine parts water to one part formalin. It was made devoid of soft tissue remnants, in order to prepare it for implants reception. The chosen areas for implant placement are the ends of femur as their bony trabacular pattern closely mimics that of the human mandible. Prior to the drilling procedure, the bovine bone was clamped in order to secure its position. Three different implant macrogeometries were chosen for this study, which were true taper, parallel wall taper and parallel walled implant designs. Some of the common thread shapes are V-shape, Square shape, buttress shaped and reverse buttress shape, as classified by Boggan et al. in 1999.Recently, spiral thread design has also been introduced. In 2008, Misch proposed that V and reverse buttress thread have 300° and 150° angle respectively.

Six implant systems that embody the above macrogeometries were chosen. Of them, the implant systems having true taper designs were Nobel active implants (Nobel Biocare, Karlskoga, Sweden) (Fig. 2a), Straumann BLX RB SL active implants (Straumann® Dental Implant, Waldenburg, Switzerland) (Fig. 2b) and Osstem TSIV SA fixture implants (Osstem Implants, Seoul, Republic of Korea) (Fig. 2c). The dimensions of the chosen implants were 4.3Ø/H13 mm, 4.5Ø/H13 mm and 4.5Ø/H13 mm respectively. The implant systems with parallel walled taper designs were Dio HSA (4008SF) implants [Dio Implants, South Korea) (Fig. 2d) and Bio3 Conus line implants (Bio3 Implants GmbH, Germany) (Fig. 2e). The dimensions of the chosen implants were 4.5 Ø/H15 mm and 4.2Ø/H13 mm. And lastly, the implant system having parallel walled design was Zimmer TSVT4B10 implant (Zimmer Biomet, Warsaw, Indiana, USA) (Fig. 2f). The dimension of the chosen implant was 4.1Ø/H13 mm. All implants used were commercially available. The implant kits corresponding to the chosen implants were used. The osteotomies were made at a speed of 900 rpm (Fig. 3) using a W&H (W&H Dentalwerk, Bürmoos, Austria) physiodispenser having its drilling speed ranging from 100-40,000rpm. It had a maximum torque of 70 Ncm (manufactured in Austria) and was operated using a foot control and had a continuous flow of coolant in order to prevent any additional heat generation during implant placement (Fig. 4). This allows the surgeon to control the speed of the drill during implant placement. The osteotomy for implant placement is created using a set of drills. Drills are tools used sequentially in order to expand the osteotomy created in the bone. Different types of drills are available. Some of the most popular have spiral, round, triflute and twist drill designs. Triflute designs are better than two-flute designs because they drill at a shorter span of time, have better cutting efficiency and reduce heat generation. More flutes may narrow the channels that form the path for bone removal, and hence should be designed in a way that easily permit debris removal. Drills can also be classified on the basis of their usage as disposable (for single usage) or reusable (used for atleast 10 surgeries). Reusable drills are mostly used in clinical practice. During the drilling procedure if the temperature exceeds 470°C for more than 1 minute, it can lead to necrosis of differentiated and undifferentiated bone cells resulting in bone necrosis and failure to achieve primary stability and in turn osseointegration. Hence, it is recommended continuous cooling with 0.9 ml NaCl, where the coolant system is attached to the physiodispenser. Drilling should be interrupted every 5-10s and coolant should be applied to the osteotomy site. For successful osseointegration of implants it is necessary that minimal heat is generated during the drilling procedure.

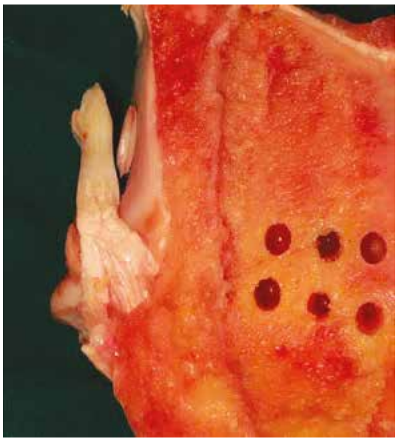


FIG. 3 Preparation of osteotomies

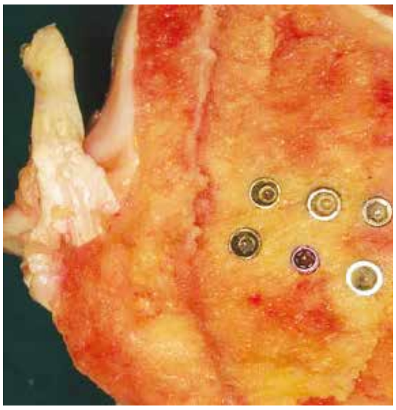


FIG. 4 Placement of implants.

All implants were placed using a motorized implant driver. Once the implant is placed into the bovine bone, a smart peg is attached onto the implant, and primary stability is measured (Fig. 5). Smartpegs are magnetized transducers, which are positioned and screwed onto the implant with a handtorque of 10Ncm. There are different smartpegs for different implant systems based on their implant transepithelial abutment connections. The machine used to measure primary stability of the implant, does so by resonance matching with a smartpeg, capable of being stimulated by magnetic pulses. Following the stimulation, the smartpeg vibrates emitting electric voltage and its resonance frequency is expressed electromagnetically as an implant stability quotient (ISQ) in a value range from 0 to 100 (Fig. 5). RFA is considered as a type of implant-

FIG. 5

bone complex bending test, wherein the transducer applies a mild lateral force simulating a small magnitude of prosthetic load, which will be applied in any clinical scenario. Some of the factors that could affect the ISQ values were implant location, implant diameter, implant length, macrogeometry and bone quality at implant site. Since these variables have been kept the same for all implants in this study, the ISQ values could be considered standardized.

Primary stability of implants were measured as a prognostic tool to determine the success of implant. All implants were placed at a speed of 900rpm using three different drilling protocols, namely: the conventional drilling, underpreparation drilling and reverse drilling techniques. In conventional drilling technique, a series of burs are used to gradually increase the size of the osteotomy in order to place the implants. Drills of increasing diameters are used, with the final drill having the same diameter as the implant being placed (2,5,6). Modifications in drill designs or sequence may be done to achieve conventional bed preparation.

In underpreparation drilling technique, a series of burs are used to gradually increase the size of the osteotomy, with the last drill being one dimension smaller than the dimension of the implant. As a result of this, the contact between implant and osteotomy walls increases, leading to better primary stability (2,5,7).

In reverse drilling protocol, apart from pilot drill and the first drill, all other drills rotate anti-clockwise during the osteotomy, while the last drill is one dimension smaller than the dimension of the implant, thus enabling bone condensation and densification along with bone cutting, thereby increasing the primary stability (2,5,6). For all three drilling techniques, company provided drills that are packaged in standard drill kits were used. Since all the drills were self-cutting, no additional bone taps were used (as per manufacturer's recommendation). Note that only the drilling technique varies not the drills. After each implant placement, their corresponding smartpegs were attached to them and their primary stability values (ISQ) were calculated in four directions, namely: mesial, buccal, distal, and lingual. Huang H et al. in their study suggested that if ISQ measurements are taken in four different spatial directions it would allow the clinicians to understand the different patterns of change in ISQ values, which would be missed if only one direction reading is taken (8).

The smartpeg numbers used for Nobel active implants, Zimmer and Bio3 was 26, Straumann BlX was compatible

Implants	Techniques	Minimum	Maximum	Mean	S.D	p value
Nobel Active	Conventional	65.67	75.50	71.23	4.08	0.00*
	Under preparation	73.00	78.50	76.27	2.15	
	Reverse drilling	79.33	83.50	81.87	2.10	
Straumann BLX	Conventional	67.00	69.33	68.53	0.95	0.013*
	Under preparation	69.00	78.17	71.67	3.76	
	Reverse drilling	70.17	80.17	75.93	4.17	
Osstem	Conventional	72.83	83.83	76.80	4.52	0.32
	Under preparation	73.83	77.33	76.03	1.37	
	Reverse drilling	76.50	80.83	78.83	1.85	
Dio	Conventional	69.83	77.33	73.67	3.44	0.017*
	Under preparation	69.67	78.17	74.10	3.69	
	Reverse drilling	77.67	81.83	79.67	1.78	
Bio 3	Conventional	67.33	79.83	72.53	4.61	0.15
	Under preparation	70.17	80.50	73.33	4.37	
	Reverse drilling	71.33	81.67	78.00	4.53	
Zimmer	Conventional	69.00	78.83	72.20	3.99	0.027*
	Under preparation	69.50	83.50	74.50	5.63	
	Reverse drilling	76.17	84.67	80.60	3.11	

**significant*

TABLE 1: Comparsion of the stability among three techniques in different implants using anova

Implants		Conventional V/s Under preparation	Conventional V/s reverse drilling	Under preparation V/s
				reverse drilling
NOBEL active	Mean diff	-5.03	-10.63	-5.6
	p value	0.056	0.00*	0.032*
Straumann BLX	Mean diff	-3.13	-7.4	-4.26
	p value	0.47	0.12*	0.18
Osstem	Mean diff	0.76	-2.03	-2.8
	p value	1.0	0.88	0.47
Dio	Mean diff	-0.43	-6	-5.56
	p value	1.00	0.029*	0.044*
Bio 3	Mean diff	-0.8	-5.4	-4.6
	p value	1.00	0.23	0.38
Zimmer	Mean diff	-2.3	-8.4	-6.1
	p value	1.00	0.031*	0.14

Significant

TABLE 2
Inter group comparsion of stability using post-hoc bonferroni

with smartpeg number 38 and for Dio and Osstem implants, smartpeg number 29 was used [as per the catalogue]. These smartpegs were compatible with the Penguin RFA machine used in this study to record the ISQ. The smartpegs and Penguin RFA machine is manufactured in Sweden by Integration Diagnostics Sweden AB. Each procedure was followed for 5 implants in each group. The research was conducted in a well-equipped area for *invitro* study in the clinic. All implants were placed by a single operator who was aware of the study. The average of these values were taken, tabulated and subjected to statistical analysis. As the data was variable and variable methods were used, statistical analysis was used for a fair outcome. To analyse this the Student t-test and ANOVA test were used on a SPSS 14.0 software (IBM, Armonk, New York, USA).

RESULTS

Comparison of drilling techniques

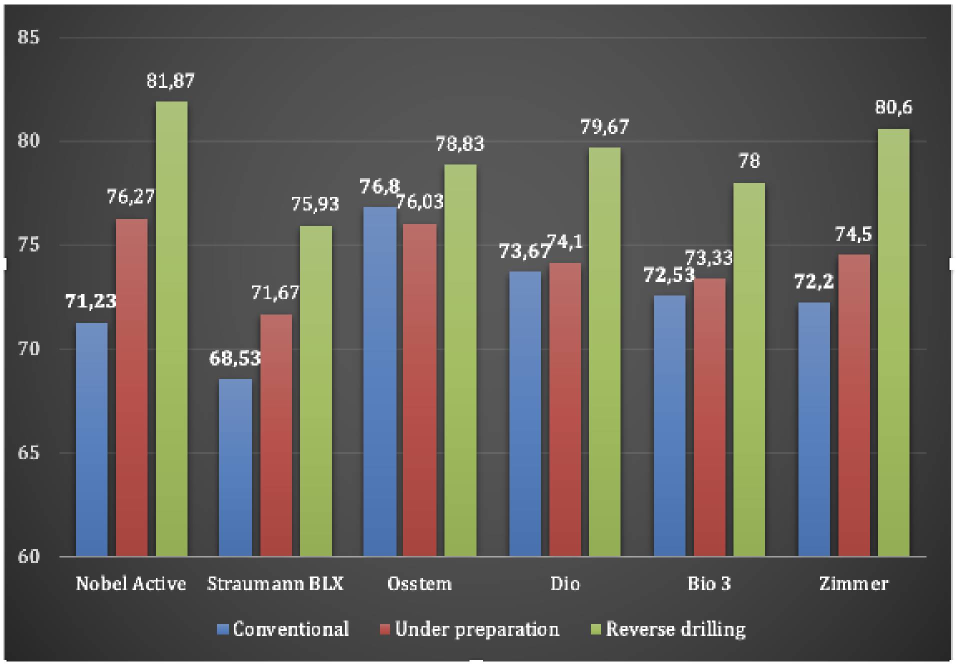
To rule out the impact of the implant design, the same thread designs were tested in all three techniques. The Penguin RFA machine was used to measure each implant's primary stability. The study showed average ISQ values of Nobel active to be 71.23 in conventional technique, 76.27 in underpreparation technique and 81.87 in reverse drilling technique. Straumann BLX implants showcased average ISQ values of 68.53 in conventional technique, 71.67 in underpreparation technique and 75.93 in reverse drilling technique. Osstem showed average ISQ values of 76.80 in conventional technique, 76.03 in underpreparation technique and 78.83 in reverse drilling technique. Dio implants showed average ISQ values at 73.67 in conventional technique, 74.10 in underpreparation technique and 79.67 in reverse drilling technique. Bio3 implants showcased average ISQ values of 72.53 in conventional technique and 73.33 in underpreparation technique and 78 in reverse drilling technique. Zimmer implants showed average ISQ values of 72.20 in conventional technique, 74.50 in underpreparation technique and 80.60 in reverse drilling techniques. The results of this study revealed that the primary stability achieved via reverse drilling technique is significantly higher compared to underdrilling and conventional drilling techniques (Table 1, 2) (Fig. 6).

DISCUSSION

Implant therapy involves placement of titanium implant into the endosseous bone(1). Natural bone has shown variations in several properties like density, stiffness, hardness and mechanical properties(7). Variations can occur in all locations in the oral cavity and in the same segment, potentially affecting the primary stability.7The type of bone had a considerable impact on the primary and secondary stability as measured by means of insertion torque, resonance frequency analysis and damping capacity (9).

Among the attributes taken into consideration to ascertain which animal model is best suited for a particular research protocol are similarity of the site to humans under physiologic and pathologic conditions (10). According to various studies considering the bone-implant interface, bone macro- structure, microstructure, and remodeling pattern should be considered while assessing and comparing the results to humans (11). *Ex-vivo* standard biomechanical tests (torque, pull-out, push-out) usually measure the amount of force or torque that causes failure of the bone-biomaterial interface surrounding different implant surfaces (11).

FIG. 6
Comparison of stability among three techniques in different implants



This protocol was used to achieve bone similarities between the experimental bovine bone and human bone in conformance with the Lekholm and Zarb classification (12),

Implant stability quotients (ISQ values) are obtained in a non-invasive method by resonance frequency measurement rapidly after surgical placement of implants (10). The ISQ-values work as indicators for mechanical implant stability, and are predictors for clinical outcome (10). A systematic review by Wu HC et al. proposed the measurement of ISQ in four directions namely mesial, distal, buccal and lingual, so that both the directions i.e which has maximum bone-implant contact and minimum bone-implant contact are included (the average values are hence taken); with the RFA device kept at a distance of 2mm away from the smartpeg (8).

Osseointegration is defined as a new structural and physiological bony contact between the implant surfaces and the pre-existing as well as neoformed surrounding bone tissues, which is formed by inherent osteogenic activities (10). Consequently, the degree of secondary stability continuously increases over time, and rapidly increases about 2.5 weeks post implantation to achieve a plateau level at about 5 or 6 weeks after implantation (10). The whole transition process from the initial primary stability phase to the finally dominating secondary stability phase roughly lasts about 5-8 weeks (10).

In clinical practice, implant stability measurements (ISQ) are used as an indirect indicator to determine the time frame for practical implant loading and as a prognostic indicator for possible implant failure (10). Given the high clinical significance of implant stability estimations, a number of methods, such as the periotest assay and resonance frequency analysis (RFA), have been employed to determine the ISQ (10).

In recent times, RFA is one of the widely used techniques to assess implant stability in clinical practice (11). RFA is performed by measuring the response of an implant-attached piezo- ceramic element to a vibration stimulus consisting of small sinusoidal signals in the range of 5-15 kHz, in steps of 25 Hz on the other element (11), The peak amplitude of the response is then encoded into a parameter called the implant stability quotient (ISQ) whose value ranges from 0 to 100 (10). The ISQ value determines the general mechanical stability of an implant (11).

With respect to spatial directions of measurements in patients, three publications (as found by the author) so far have concluded that the measurements from different directions do not lead to significant differences in the ISQ measurements (10). However, some studies suggest that if two different spatial directions were to be used this may allow clinicians to detect different patterns of ISQ changes that would otherwise not be identified if only one direction of measurement was applied (11).

Another factor that was believed to influence implant stability (and thus ISQ measurements) was the gender of the patient (9). Males were found to have either significantly higher, or significantly lower ISQ values in comparison with females, or they yielded similar results (9).

According to location within the dental arch, statistical analyses indicated higher ISQ values were found for anterior implants than for posterior (10). However, in other studies no significant differences were found among ISQ values relating either implants in the anterior or posterior mandible, or the anterior maxilla (10). It was also reported that the ISQ values of implants are typically

higher in the mandible (ISQ≈59.8) compared to those placed in the maxilla (9).
Number of other studies showed that implant diameters could influence ISQ values; more specifically, it was found that when the implant diameter increased the ISQ values also increased (10).
Various clinical studies reported that implant length does not majorly influence primary stability of implants .In contrast to these clinical data, several in-vitro studies reported that longer implants are typically associated with higher ISQ values than shorter ones (11).
As per the influence of implant design on ISQ measurement, only few publications were found among which one stated that, the implant design did not have a significant influence on the implant stability quotient (9). In this study, a comparison was made between an implant body design without self-tapping blades with an implant type with self-tapping blades. However, the basis of the absence of a difference of the ISQ values remained inconclusive (10).
Implant showcasing micromovement over 150 microns was considered a potentially failing implant, following loss of bone contact interface and fibrous soft tissue is often seen to be interposed between bone and implant(13). In 2007, Scarano et al. classified ISQ to understand the stability of the said implant(13). According to this classification, ISQ below 60 was said to have low stability, ISQ between 60-70 was considered to have medium stability and implants with ISQ higher than 70 was considered to have high stability(13). In 2013 Huang et al. proposed that implant geometry with higher quality of threads and lower pitch had the best stability and that implant thread design indeed had an impact on primary stability(13).
In a number of publications, the time intervals chosen between primary and secondary stability values were arbitrarily chosen, and were often found to be defined at 6 weeks, at 12 weeks, or at 16 weeks intervals for monitoring purposes of implant stability(9). Lang et al. recommended to monitor implant stability by RFA at earlier time points, i.e. at 3 weeks and 8 weeks post-surgery(12).
In many publications , it has been suggested that the use of a specific surgical technique is important to improve the post- surgical implant stability quotient(10). For example it was reported that the application of the osteotome expansion technique is associated with a significant improvement in secondary stability results, and the use of the osseous densification technique was reported to increase the degree of primary stability achievement(9). The technique also influences the resulting bone mineral density as well as the percentage of bone coverage of the implant surface when compared with conventional drilling techniques(9).
In a study conducted by Attanasio F et al. , a comparison between Summer's osteotome protocol and bone compactors protocol, both of which worked on the principle of lateral bone compression, it was proven that implants placed using these two techniques gained superior primary stability than when placed using conventional drilling technique(14).
A new technique relating to piezoelectric-based surgery, as described by Stacchi et al., was reported to decrease ISQ values to a smaller degree and resulted in an earlier shifting from a decreasing to an increasing stability pattern, when compared with the traditional drilling technique(10). Conventional implant placement techniques and those using Summer's Osteotome technique were reported to also influence stability results assessed by ISQ measurements(10). However, two different clinical studies report that osteotomy preparation by either standard or soft bone surgical protocols does not lead to significantly different implant survival results nor to any differences in postoperative stability data for the specific implant designs used(11).
Several studies have been conducted on resonance frequency analysis (RFA) measurements and the ISQ. They provided valid indication that accepted stability range is above ISQ 50 and recommended loading at ISQ 67-68(15).
Meredith et al introduced a method based on the frequency analysis of the implant's response to a transducer excited with a proper, steady-state wave form. The method, resonance frequency analysis (RFA), measures the stiffness of the implant with respect to the surrounding tissue, thereby providing a quantification of its mechanical stability, expressed as the implant stability quotient (ISQ). This method seems to provide more reliable information in comparison with other tests (16).
For this test, the transducer was screwed onto each implant and tightened to 5 to 10 Ncm. The device probe was aimed at the small magnet placed on the top of the transducer and held still, at a distance between 2 and 3 mm, until measurements were complete and the device displayed the ISQ value(16). If two ISQ values were displayed simultaneously, their mean value was taken into consideration. Measurements were taken twice in the buccolingual direction and the mesiodistal direction.16 The mean of all measurements was rounded to the nearest integer and considered as the ISQ.
Micromotion at the bone-implant interface, when exceeding a 50- to 150-μm threshold, led to formation of fibrous instead of bone tissue, hindering osseointegration(16). It has been proven that insertion torque scores less than 20 Ncm are predictive of a greater failure rate for immediately loaded implants. If RFA is considered, failure rates rise exponentially when the ISQ is less than 55. (16)
Implants recieve primary stability by the residual alveolar bone at the apical position, while a part of the implant surface is encapsulated by the clot or the graft and undergoes osseointegration over time as bone regeneration occurs around the implant (16).
Ottoni et al. showed a reduction in failure rate of 20% in single-tooth implant restoration for every 9.8 N cm of torque increased (17).

A statistically significant relationship between IT and marginal bone loss was yielded favoring lower IT values. Each increase of 1 IT unit stands for a marginal bone loss of 0.01 mm (18).
Early findings suggested that low IT at implant placement might be associated with future fibrous encapsulation of the implant, as a result of the occurrence of implant micromotion(18).
In case of poor bone quality , it was proven that implant with deeper threads, and decreased thread pitch could be used to increase initial bone implant anchorage. This principle can be applied to different implant thread designs namely, V-shaped, buttress, reverse- buttress, and trapezoid (4). However, each thread design is thought to give a varying degree of apical and lateral compression to the surrounding bone, which will produce a definite amount of osteocompression and primary stability(4).
Huwais and Meyer introduced the bone compaction technique through the osseodensification drilling, and claimed that it increased the insertion torque, bone-to-implant contact, and accordingly resulted in greater primary stability compared to conventional drilling and to Summers osteotome technique (4). This hypothesis has been confirmed by the work of Lahens et al. who reported a considerably higher bone-to-implant contact for osseodensification, and Lopez et al. who tested the osseodensification technique in vivo and reported its significant success over conventional drilling mechanically using the pull- out testing and microscopically using the histomorphometric techniques(4).
As per the findings of Abuhussein et al., the implants used in his study had deep threads with a decreased thread pitch to ensure bone anchorage, and based on the conclusion of Chong et al., in implants without self-tapping properties, the threads were thought to provide higher primary stability than self-tapping threads(4).
Osseodensification (OD) burs, working in a non-subtractive fashion, condense the implant osteotomy soft bone in lateral direction, leading to a greater bone volume and density, inturn producing increase in the bone implant contact, with obvious increase in insertion torque levels, and gradual reduction in micromotion(4).
The rationale behind this technique is that the densification of the bone that will be in immediate contact with the implant results in greater primary stability due to physical and mechanical interlocking between the bone and the device, and there will be faster new bone formation due to osteoblasts nucleating in proximity with the implant(19).
Meredith et al. were supporting this review, when stated that RFA could serve as a useful research technique and is a valuable tool in studying the behaviour of implants in relation to surrounding tissue (19).
Several techniques for the management of inadequate bone volume have been developed like alveolar ridge expansion/splitting techniques and, in many scenarios, allow for simultaneous implant placement (20). With these techniques, a series of osteotomes, chisels or screw-type expanders have been used to locally expand the developing osteotomy site (20).
An elastic rebound and a spring-back effect was documented post osseodensification (20). Hence , post implant placement, the rebound of bone on the implant surface may increase the immediate to early bone-to-implant contact during healing, facilitating the autografted bone particulate to be held firmly against the implant. This improves the primary stability of the implant and potentially maintains higher stability values all through the healing process (20).
It was also concluded that during osteotomy, there should not be excessive heat generated at the site of placement as it can lead to bone necrosis.
In vivo temperature measurements can be executed using thermocouple or thermography (21). Thermographic methods refer to the noninvasive observation of bone drilling procedure. Thermographic camera shows the changes in temperature in the external surface of bone and visible part of the drilling tool (21). However, the whole surface of drilling tool was investigated even after the bone canal creation. Infrared thermography is noninvasive and completely safe for the patient. In this method heat emission is calculated during drilling the osteotomy in the bone (21).
Study revealed that during dental implant site preparation a temperature exceeding 47°C negatively impacts bone-implant osseointegration. In addition, the above-mentioned study demonstrated that drilling time below 1 minute and temperature not exceeding 47°C can lead to successful implant osseointegration (21).
On the other hand, studies by other authors showed that temperature above 50°C, along with extended preparation time induces thermal necrosis (20).
A study conducted by De SanJose LF et al. compared ostetomies created using conventional drilling technique at 800rpm with and without irrigation and at 45 rpm with and without irrigation, and it was seen that the osteotomies prepared without irrigation in both the groups led to failure of placed implants due to excessive heat generated at the site, leading to bone necrosis(22). Hence, continuous irrigation via a coolant was deemed mandatory during implant placement(22).

CONCLUSION

Within the limitations of the above-mentioned study, it can be concluded that there could be an influence of different thread design on primary stability when three different drilling techniques are used as suggested by statistical analysis.As per the results obtained in this study, reverse drilling protocol showed the highest primary stability followed by under drilling technique and then conventional technique when implants are placed at speed of 900rpm.But the author would like to recommend that various designs and lengths of the implant can also be included and the study could also be conducted on different bone types or cadavers in the future to strengthen the present outcome of the study.

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