

To Determine and Compare the Dental Implant Stability using Insertion Torque and Resonance Frequency Analysis Techniques

Nonika Chahal, Ritu Batra, Varun Arora, Neeraj Mittal, Kamalpreet Kaur, Shivani Garg

Department of Prosthodontics and Crown and Bridge and Implantology, J.C.D Dental College, Sirsa, Haryana, India.

Abstract

Background: The aim of the study is to compare and correlate implant stability measured using a hand ratchet with an insertion tool and resonance frequency analysis (RFA). **Materials and Methods:** A total of 20 patients with edentulous/partial edentulous conditions in relation to both maxillary and mandibular arch were selected for the study based on inclusion and exclusion criteria. Implants were placed at crestal and subcrestal levels. Insertion torque (IT) values were recorded using a calibrated torque wrench. RFA (Osstell implant Stability quotient) at the time of placement and at the time of loading was evaluated. The collected data were statistically analyzed using Spearman's rho correlation coefficient test and paired *t*-test. **Results:** On the evaluation of primary stability, in both crestal and subcrestal implants using IT and RFA, the *p*-values for crestal and subcrestal implants were 0.700 and 0.632, respectively, which signifies no statistically significant difference in terms of evaluation of primary stability between two levels of implant placements. While as on the evaluation of secondary stability using RFA in both crestal and sub-crestal implants, the *P*-values were 0.141 and 0.017, respectively, which signifies no statistically significant difference in terms of evaluation of secondary stability between the two levels of implant placements. **Conclusion:** Within the limitations of this study, it can be concluded that both the methods are equally acceptable and reliable and both are independent of each other as there was no significant correlation found between the two both at crestal and sub-crestal levels of implant placement.

Keywords: Implant stability quotient, Implant stability, Implant, Insertion torque value, Resonance frequency analysis.

INTRODUCTION

Fixed prosthodontics aims at restoring the function, comfort, and esthetics of missing teeth. Osseointegrated dental implants offer effective solutions for such clinical situations.

The successful outcome of any implant procedure needs a series of patient-related factors (bone volume and density) and procedure-dependent parameters (type of implant and surgical procedure) to be considered.^[1]

One of the factors involved in the success of osseointegration and the long-term success of implants is implant stability, which is defined as the biometric stability of the implant after its placement within the bone.^[2]

The greater the primary stability, the lesser the micro-motions between the implant surface and surrounding bone. Thus, facilitating uninhibited healing and sound osseointegration.^[3]

Intimate contact of the implant with bone can be checked by measuring primary stability. The traditional gold standard

used to assess the intimate contact between bone and implant was microscopic and histological analysis. However, due to the invasiveness of this method and the associated ethical issues, various other non-invasive methods are being used such as the surgeon's perception, radio-graphical analysis, cutting torque resistance, insertion torque (IT) analysis, reverse torque, resonance frequency analysis (RFA), model analysis, and Periotest.

The overall aim after implant placement concerning the peri-implant bone height is to minimize marginal bone loss. It has been hypothesized that implant neck designs and

Address for correspondence: Dr. Nonika Chahal,
Department of Prosthodontics and Crown and Bridge and Implantology,
J.C.D Dental College, Sirsa, Haryana, India.
Email: nonikachahal0001@gmail.com

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implant insertion depths, in particular, the positioning of the implant shoulder in relation to the alveolar bone crest may impact crestal bone resorption observed around end-osseous implants.^[4]

With regards to implant height, oral endosseous implants can generally be placed supracrestal, equicrestal, and subcrestal depending upon clinical situation and design protocol.

The present study was conducted to compare and correlate the calibrated values of implant primary and secondary stability measured using a hand ratchet with an insertion tool and RFA in implants placed at crestal and sub-crestal levels.

MATERIALS AND METHODS

Twenty patients with partial edentulous and/or completely edentulous conditions were included in the study based on exclusion and inclusion criteria. A detailed clinical, hematological investigation, and radiographic examination were done on selected patients. Patients were informed about the treatment and a consent form was obtained.

Patient criteria

Inclusion criteria

1. Patients with adequate bone volume without bone augmentation were included in the study
2. Patients should not be suffering from any systemic disease, endocrine disorders, or blood dyscrasias were selected
3. Patients should be non-smokers to eliminate the errors of crestal bone loss.

Exclusion criteria

1. Patients with pathological osseous lesions were excluded from the study
2. Patients with severe bruxing or clenching habits were excluded from the study
3. Patients with inadequate oral hygiene were excluded from the study
4. Patients within sufficient bone or any other bone abnormality that interferes with implant placement were excluded from the study
5. Patients with medical conditions requiring prolonged use of steroids & NSAIDS were excluded from the study
6. Patients with persistent intra-oral infections were excluded from the study.

Surgical placement of an implant at the site

Root form endosteal implants were placed using a manual calibrated torque wrench. Both crestal and subcrestal implant placements were placed as per the prosthetic demand.

Assessment of implant stability using IT wrench and RFA

Primary stability

For assessment of primary stability, the IT value for each implant was measured in Ncm by means of the calibrated torque wrench and was noted down and the implant stability quotient (ISQ) values were assessed using the RFA.

Secondary stability

To evaluate secondary stability, the patients were recalled after 3 months. After removing the cover screw the smart peg was attached to the implant and ISQ values were again obtained using the RFA as earlier. The values were noted down and calibrated. After the calibrations, the implants were covered with healing/gingival collars which were at least 1 mm above the peri-implant soft tissue depending upon the mucoperiosteal thickness. After calibrations, the prosthetic phase was started as per the second stage protocol.

RESULTS

The mean ISQ values of each patient and the ITV were statistically analyzed at the crestal and sub-crestal level of implant placement.

The evaluation of primary stability in crestal implants using both ITV and RFA on comparison showed insignificant differences between the two methods. At the time of insertion of subcrestal implants, no statistically significant difference was also found between the RFA and ITV methods. However, 70% of subcrestal implants had ITV <35 Ncm.

The mean ISQ values for crestal implants at the insertion on both buccal and lingual sides were 59.5000 and 59.0000, respectively, while for subcrestal mean ISQ values on buccal and lingual sides were 61.6000 and 61.7000, respectively (Table 1). The mean RFA values of subcrestal implants on both buccal and lingual sides are greater than crestal, but the *P*-values for crestal and subcrestal implants on buccal and lingual sides were 0.700 and 0.632, respectively, this signifies that statistically, there is no significant difference found between two levels of implant placements.

On comparison between ITR and RFA of both crestal and subcrestal levels of implant placement at the time of implant insertion, there was no significant difference found between the two methods of recording and two levels of implant placements.

The mean ISQ values for crestal implants at the time of recovery, 3 months Post-insertion on both buccal and lingual sides were 71.2000 and 69.9000 respectively, while for subcrestal mean ISQ values on buccal and lingual sides were 75.1000 and 77.2000, respectively (Table 2).

Table 1: Comparison between ISQ value of implants placed at crestal and subcrestal level at the time of implant placement (primary stability)

ISQ level	Implant type	n	Mean	Standard deviation	P-value
ISQ buccal insertion	Crestal	10	59.5000	14.08900	0.700, NS
	Subcrestal	10	61.6000	9.39503	
ISQ lingual insertion	Crestal	10	59.0000	14.39907	0.632, NS
	Subcrestal	10	61.7000	9.94485	

ISQ: Implant stability quotient

Table 2: Comparison between ISQ values of implants placed at crestal and subcrestal level at the time of recovery before functional loading (secondary stability)

ISQ	Implant type	n	Mean	Standard deviation	P-value
ISQ buccal functional loading	Crestal	10	71.2000	6.08824	0.141, NS
	Sub- crestal	10	75.1000	5.19508	
ISQ lingual functional loading	Crestal	10	69.9000	6.34998	0.017, S
	Sub- crestal	10	77.2000	6.03324	

ISQ: Implant stability quotient

Although the mean ISQ values for subcrestal implants are higher, the *P*-values for crestal and subcrestal implants on buccal and lingual sides were 0.141 and 0.017, respectively, this signifies an insignificant statistical difference between the two levels of implant placements. While comparing between primary stability and secondary stability of implants placed at crestal and subcrestal levels using RFA, it was observed that there was no significant statistical difference between the two groups.

Using Spearman's Rho correlation coefficient test, the implants placed at crestal and subcrestal levels, showed no significant difference between the two.

On comparison between ITV and RFA, it was observed that both the methods are equally acceptable and reliable and both are independent of each other as there was no significant correlation found between the two methods of measuring implant stability.

DISCUSSION

Implant stability is one of the essential parameters to check and calibrate whether we have achieved good osseointegration.^[5] It can be either primary or secondary depending on the time of evaluation. The primary stability is considered a significant factor for the secondary stability. It, thus, prevents the formation of a connective tissue layer between implant and bone consequently ensuring bone healing.^[6] It depends on the bone quantity and quality (patient factor), surgical technique (surgeon factor), and the implant geometry, length, diameter, and surface characteristics (implant factor). While secondary stability depends on the primary stability, bone remodeling, and implant surface condition.^[7,8] The maintenance of the crestal bone level around dental implants is essential for their long-term success and survival. A marginal bone loss of <1.5 mm in the 1st year and 0.2 mm in the following years is acceptable after implant loading. However, with the current emergence of new alloys, new designs (micro design and macro design), and new implant surface treatments the bone loss around implants is typically less than previously accepted as defining success. Several treatment protocols have been proposed to reduce the marginal bone loss around implants, where the level of implant position with respect to alveolar bone is critically an important

factor.^[9] With respect to the crest of the bone, implants can generally be placed supracrestal, equicrestal, or subcrestal.

On the difference in bone loss between crestal and subcrestal placements reported, non-significant results were shown between the two positions.^[10]

Barros *et al.*^[11] found that vertical bone resorption was decreased in the subcrestal groups compared to the equicrestal groups, but the difference was not statistically significant. However, a peak of crestal bone was frequently observed between the implants placed subcrestally, whereas a flattened aspect of the crestal bone was observed in the equicrestal implants.^[11]

On the other hand, the authors who defend a crestal position of the implant obtained evidence that demonstrates an increase in bone loss when the implant is placed subcrestally.^[12] Both crestal and subcrestal implant placement approaches are clinically favorable in terms of survival.^[13]

In our study, on evaluation of primary stability, in both crestal and subcrestal implants using IT and RFA, the *P*-values for crestal and subcrestal implants were 0.700 and 0.632, respectively, which signifies that statistically, there is no significant difference found in terms of evaluation of primary stability between two levels of implant placements.

While on the evaluation of secondary stability using RFA in both crestal and sub-crestal implants, the *P*-values were 0.141 and 0.017, respectively, which signifies that statistically, there is no significant difference found in terms of evaluation of secondary stability between the two levels of implant placements.

In our study, IT is used to calibrate only the primary stability.

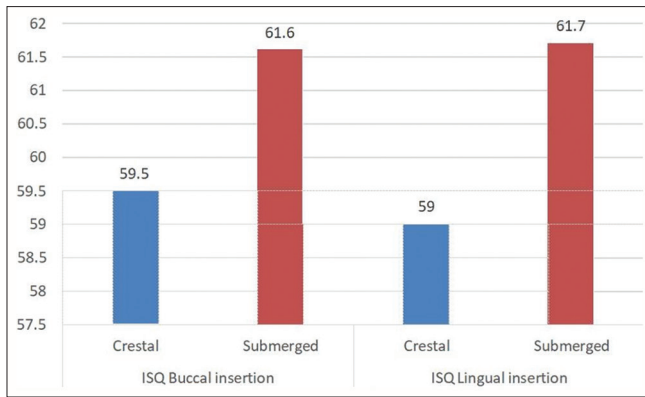
Though IT in the range of 35 Ncm has been found satisfactory,^[14] some clinicians may prefer higher or lower IT.^[15]

In our study, it was found that the ITVs between 35 Ncm and 50 Ncm in both crestal and subcrestal implants which is in accordance with a few other authors^[16,17] who also suggested that the ITV of 35 Ncm is satisfactory for good osseointegration and for immediate loading, while the highest IT can be 50 Ncm and higher than 50 Ncm could lead to higher peri-implant bone loss (Lages FS *et al.*)^[18] while Ostman PO *et al.*^[19] in their study concluded that high torque does not induce bone necrosis in dense cortical bone, and that high torque (mean 110 Ncm) is important for increased primary stability and for immediate loading protocol.

Although this method is clearly a subjective feeling it can give an experienced operator a level of confidence in the prospects of a successful outcome for a case.^[15]

In our study, on comparison between the ITVs of crestal and subcrestal implant, the *P* = 0.137, which signify no statistically significant difference among the two study groups.

RFA allows clinicians to measure implant stability at different time points in the process of osseointegration to assist in



Graph 1: Comparison between implant stability quotient value of implants placed at crestal and sub-crestal level at the time of implant placement (primary stability)

functional loading decision-making.^[20] RF values are computed in Hertz by a simple recalculation method, and then they are converted into the ISQ, usually on a scale of 1–100 ISQ units.^[20] In our study, the primary stability of implants was analyzed using both RFA and IT. We used Osstell ISQ to analyze the stability of implants. ISQ values we obtained at insertion were between 49 and 74, with an average range of 60 ± 5 . The mean ISQ values for crestal implants at the insertion on both buccal and lingual sides were 59.5000 and 59.0000, respectively, while for subcrestal mean ISQ values on buccal and lingual sides were 61.6000 and 61.7000, respectively (Graph 1).

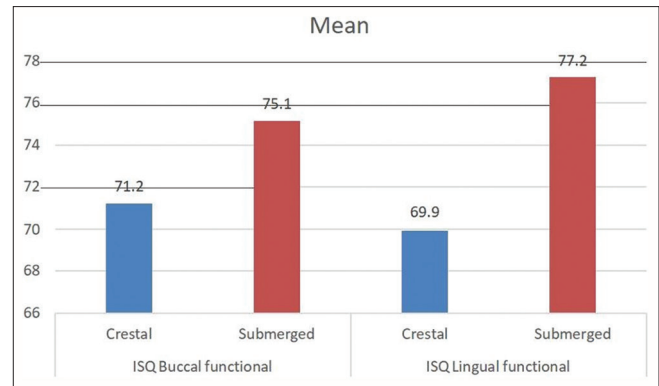
While the mean RFA values of subcrestal implants on both buccal and lingual sides were greater than crestal, the *P*-values for crestal and subcrestal implants on buccal and lingual sides were 0.700 and 0.632, respectively, this signifies that statistically, there was no significant difference found between two levels of implant placements.

For secondary stability, the ISQ values we obtained at the time of uncover were between 57 and 86, with an average range of 71 ± 5 . The mean ISQ values for crestal implants at the time of recovery, 3 months Post-insertion on both buccal and lingual sides were 71.2000 and 69.9000, respectively, while for sub-crestal mean ISQ values on buccal and lingual sides were 75.1000 and 77.2000, respectively. Although the mean ISQ values for subcrestal implants are higher, the *P*-values for crestal and sub-crestal implants on buccal and lingual sides were 0.141 and 0.017, respectively; this signifies an insignificant statistical difference between the two levels of implant placements (Graph 2).

Many authors have suggested different ISQ values for good implant stability. From an ISQ of at least 55,^[21] 60^[22] to an ISQ of 65^[23] is considered good for initial stability.

According to some studies,^[24] there is a positive correlation between ISQ and IT, while other studies show no correlation.^[25]

This difference in results may be related to the different methods used in different studies. The present study showed that there was no correlation between IT and initial ISQ.



Graph 2: Comparison between implant stability quotient values of implants placed at crestal and sub-crestal level at the time of recovery before functional loading (secondary stability)

The ISQ value indicates the resistance to bending load while IT indicates the frictional resistance.^[26]

There are several studies that found no statistically significant correlation between the RFA and IT. Akça *et al.*^[27] could not find any relationship between RFA and torque in an *in vitro* study of 16 implants. Degidi *et al.*^[28] and Cehreli *et al.*^[29] found no correlation between the two values. On the other hand, in several studies^[30] a strong correlation between ITVs and ISQ values was described.

However, the present study has certain limitations such as the smaller sample size, amount of vertical displacement of subcrestal implants, and no site specification that could effect of bone quality and density on ISQ values. To overcome the limitations of this study, a large sample size could be included; the use of cone beam computed tomography can be considered for accurate bone density measurements, etc.

CONCLUSION

Within the limitations of this study, it can be concluded that both the methods of measuring implant stability are equally acceptable and reliable and both are independent of each other as there was no significant correlation found between the two both at crestal and subcrestal levels of implant placement.

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