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Immediate loading of dental implants placed with Osseodensification technique in Maxillary Posterior region of jaw

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ABSTRACT

Implant placement and immediate loading in the maxillary posterior has always been a challenge because of various conditions like less dense bone, etc. Osseodensification has proven to be a superior technique to improve the overall success rate of implant restorations. This study is done on 28 patients with maxillary posterior missing teeth (n=14 each). The implant stability (using the RFA method) and crestal bone levels are evaluated at the time of implant loading and at the end of 3 months. The osseodensification technique turns out to be the superior osteotomy preparation technique to the conventional one in terms of stability and crestal bone loss in immediately loaded dental implants placed in the maxillary posterior region.

Keywords: *ossendensification, immediate loading, ISQ, posterior maxilla, dental implants*

1. INTRODUCTION:

The replacement of teeth by means of implants is a predictable treatment with a high success rate.[1] Achieving implant stability, which is achieved at the bone-implant interface is mandatory for the success and survival of dental implants.[2,3,4] This stability can be influenced by patient variables like the surgical site, surgical technique, and implant design.

During osteotomy preparation, the maintenance and preservation of bone leads to enhanced primary stability, and enhanced Bone Implant Contact (BIC), thereby enhancing the implant's secondary stability.[5]

The conventional technique, based on the principle of osteosubtraction, uses standard drill designs that excavate bone fragments to create room for implant placement.[5,6] The insufficient bone around the implant negatively influences both primary and secondary stability.[6]

Osseodensification, a non-extraction technique, was developed by **Salah Huwais** in 2013 and made possible with specially designed burs to increase bone density as they expand an osteotomy. Also, it is concluded that, by reserving bulk bone, the healing process would be accelerated due to bone matrix, cells, and biochemicals maintained and autografted along the osteotomy surface site.[7]

The immediate occlusal loading protocol is an implant-supported temporary or definitive restoration in occlusal contact placed within 2 weeks of the implant insertion. A non-functional immediate restoration is an implant prosthesis with no direct occlusal load within 2 weeks of implant insertion and is considered primarily in partially edentulous patients.[8]

Thus, the aim of this clinical study was to evaluate and compare the conventional and osseodensification techniques in terms of implant stability and crestal bone loss around immediately loaded implants in the maxillary posterior region.

2. MATERIALS AND METHODLOGY:

The study was conducted in the Department of Prosthodontics with the approval of the institutional ethics committee.

2.1 Sample size calculation:

The sample size was determined using the mean and standard deviation values from the literature using the formula

$$n = 2(Z_\alpha + Z_\beta)^2 [s]^2 / d^2$$

(approximately 14 sites per group need to be taken in the present study)

The study was conducted on 28 partially edentulous subjects, in the age group of 25-50 years, reporting to the Department of Prosthodontics for the replacement of missing maxillary posterior teeth.

Patients were randomly divided into two groups of 14 patients each, as follows:

Group I	implant placement with conventional osteotomy preparation technique at 14 sites and loaded immediately
Group II	implant placement with osseodensification osteotomy preparation technique at 14 sites and loaded immediately

2.2 Inclusion criteria –

1. Patients in the age group of 25-50 years
2. Patients with completed skeletal growth
3. Patients with single or multiple missing teeth in the maxillary posterior region
4. Sufficient bone support in the prospective implant site
5. A patient who is medically fit for surgery and with no contraindications for surgery under Local Anaesthesia
6. A patient who will strictly follow and maintain proper oral hygiene
7. Healed sites with a minimum three-month post-extraction healing period

2.3 Exclusion criteria –

1. Presence of persistent and unresolved infection at the implant site
2. Chronic smokers, patients who have drug or alcohol dependency
3. Patients undergoing radiotherapy or having a history of chemotherapy or radiotherapy to the head and neck region

4. Patients suffering from debilitating systemic diseases like hypertension, diabetes, etc.
5. Poor bone volume
6. Active periodontal disease
7. Patients with parafunctional habits
8. Female patients who are pregnant

Subjects were selected irrespective of their gender, caste, creed, and socioeconomic status. All patients were provided with written and verbal information about the study and those who fulfilled the criteria were invited to participate in the study. An informed consent was obtained from the patients and they had the right to withdraw from the study at any time, without consequences to their future care. A detailed case history was obtained from each subject. All required periodontal and restorative treatments, including oral hygiene instructions, non-surgical therapy, and endodontics, were performed prior to implant placement.

2.4 Procedure:

A standardized implant placement protocol according to the manufacturer’s recommendations was used for implant placement. To prevent the bias caused by inter-operators, one operator completed the survey.

Pilot drills followed by subsequent drills of increasing diameters were used to perform the osteotomy procedure, with both conventional (group I) and osseodensification (group II) drills in the planned region, for planned implant diameters. After the completion of osteotomy to the estimated length and diameter, implants were placed in the osteotomy site using a surgical wrench, the torque ranging between 30-40Ncm. Radiographic analysis of the crestal bone level and measurement of the stability of the implants was done immediately after the placement of dental implants.

Implant stability was measured with the Osstell ISO® device which is based on resonance frequency analysis (RFA). Radiographic analysis was done with the help of a digital x-ray machine for both groups. To avoid magnification errors, a lead grid was used before taking a radiograph.

In both groups, a one-stage surgical procedure was performed and implants were placed with respective techniques. The open tray impression coping was then attached over the implant and a single-step open tray impression was made with silicone putty and light body impression material. Then healing abutment was placed over the implant and suturing was done.

The impression made was disinfected. Implant analogues were attached to the open tray impression copings in the impression and casts were poured in die stone. Customized temporary abutments were screwed onto the implant analogs on the master casts and the screw-retained nonfunctional (prosthesis without any direct occlusal contact) immediate provisionals were fabricated and fixed over the abutments. Provisionals were custom-made using a silicon index obtained from the diagnostic wax-up. Digital intraoral periapical radiographs were taken perpendicular to the long axes of implants immediately after loading and 3 months after loading of implants, with a long cone paralleling technique.

The first thread of the implant was taken as the reference line since it is static, permanently visible, and easy to locate on all radiographs. The point of bone-implant contact (BIC) was chosen as the crestal bone level. The measurement was done by dropping perpendiculars from the reference lines to the bone levels with the use of radiovisiography using ADSTRA imaging RVG software.

Suture removals were done 7 days postoperatively. Following the suture removal, the patient was recalled at 3 months for implant stability and radiographic analysis of the crestal bone level of both groups.

For both groups, the provisionals were retained on the abutments until the fabrication of permanent restoration. The customized abutments were designed according to the profile of the peri-implant mucosa. Resonance frequency analysis was performed for implants in both the groups immediately after placement and loading of implants and after 3 months of loading.

3. RESULTS:

Table 1 and Graph 1 depict the difference between the means of implant stability (S) of group I implants at immediate implant loading (baseline) (primary stability) and 3 months after loading (secondary stability).

Table 2 shows the intra-group comparison of means of mesial crestal bone level of implants at baseline (M_1) and after 3 months of loading (M_2).

Table 3 shows the intra-group comparison of means of distal crestal bone level of implants at baseline (D_1) and after 3 months of loading (D_2).

TABLE 1:

Technique and Time	Sample	Mean ± SD	Mean Difference	p- Value
CS_1	14	75.57±2.95	3.28	0.006**
CS_2	14	78.85±2.74		
OS_1	14	79.71±3.17	7.35	0.001**
OS_2	14	87.07±3.12		

[# - Not significant (P ≥ 0.05), * - Statistically significant (P < 0.05), ** - Highly significant (P ≤ 0.01)]

TABLE 2:

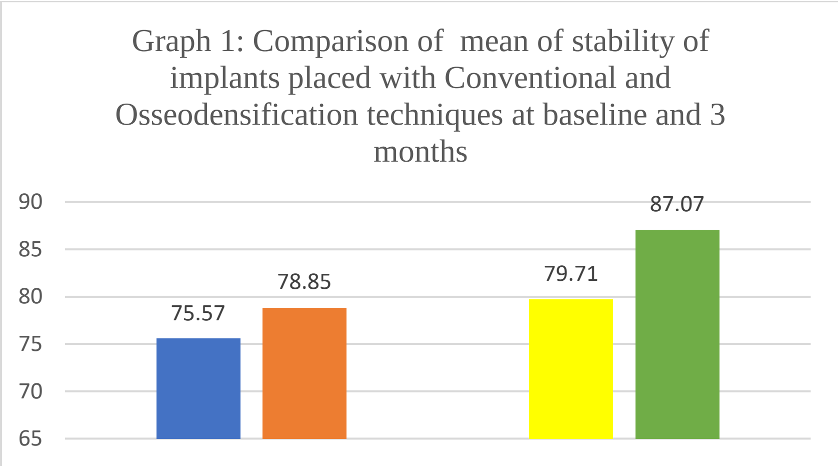
Technique and Time	Sample	Mean ±SD	Mean Difference	p- Value
CM_1	14	1.08± 0.14	0.40	0.001**
CM_2	14	0.67 ±0.12		
OM_1	14	1.14±0.12	0.38	0.12#
OM_2	14	0.76±0.26		

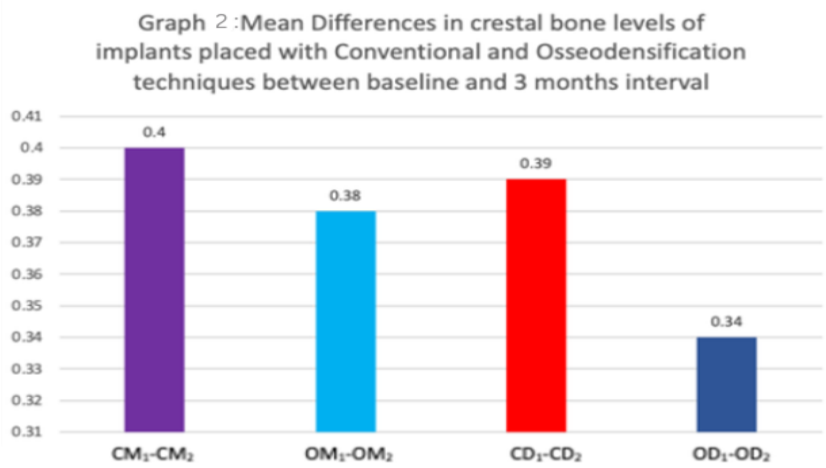
[# - Not significant (P ≥ 0.05), * - Statistically significant (P < 0.05), ** - Highly significant (P ≤ 0.01)]

TABLE 3:

Technique and Time	Sample	Mean ±SD	Mean Difference	p- Value
CD_1	14	1.08±0.14	0.39	0.001**
CD_2	14	0.68±0.10		
OD_1	14	1.14±0.12	0.34	0.15[#]
OD_2	14	0.79±0.27		

[# - Not significant ($P \geq 0.05$), * - Statistically significant ($P < 0.05$), ** - Highly significant ($P \leq 0.01$)]





4. DISCUSSION:

The phenomena of osseointegration of titanium implants were discovered by Swedish orthopedic surgeon, **PI Branemark**, in 1952, who defined osseointegration as "a direct structural and functional connection between ordered living bone and the surface of a load-carrying implant".

There are various loading protocols for dental implants. Cochranereviews are recognized as a gold standard in evidence-based health care. Recently, Weber et al[9] presented (2009) loading protocols, and Esposito[10] and co-workers published (2007) an updated version of their systematic review regarding different times for loading dental implants, based on it, Immediate loading was defined as implants in function within 1 week after their placement. No distinction was made between occlusal and non-occlusal loading.

The patient's desire to shorten the treatment period and to avoid an edentulous condition encouraged the introduction of an immediate loading protocol. [11]

4.1 **Stability analysis:**

According to **Albrektsson et al[12] (1998),** the Initial stability of the implants is one of the most important factors for successful osseointegration. Achieving stability depends on the bone density, the surgical technique, and the microscopic and macroscopic morphology of the implant used.

In **1998, Meredith[13]** concluded that the RFA technique was consistently more accurate and sensitive in detecting changes in implant stability than conventional clinical and radiographic examination techniques. More correlation of RFA with histomorphogenic parameters than periotest measurements was found by **Nkenke[14]** and co-workers in **2002**. Thus, the Osstell ISQ instrument was used in this study as it was proven to consistently provide accurate, reliable, and repeatable values of the stability of implants at various time intervals and the technique is non-invasive.

In the current study, the implant stability is found to be significantly increased in both the techniques used, from baseline to 3 months (table 1). But implants placed with the osseodensification technique showed statistically significant higher values of both primary and secondary stability and hence were found to be more effective as compared to the conventional technique. Similar results were also reported by **Huwais S[15] et al** in 2017. Huwais S introduced the bone compaction technique through OD drilling and claimed that it increased the insertion torque, and bone-to-implant contact, and accordingly resulted in greater primary stability compared to conventional drilling. This hypothesis was also further reported by **Lahens B[16] et al** and **Lopez C[17] et al**.

Another reason accounting for increased stability in the osseodensification technique could be to use of Densah Bur. This bur allows the clinician to increase the primary stability at implant insertion by densifying the surrounding osseous environment. This is done through non-subtractive drilling. According to **Lahens B et al** in 2016 the conventional drilling process uses a positive rake angle to extract a small thickness of material with the passing of each flute creating an osteotomy with no bone residue remaining in the hole, whereas the osseodensification drilling process does not excavate bone tissue rather it is autografted in outwardly expanding directions from the osteotomy.

The osseodensification drilling process begins with the creation of an osteotomy using a tapered, multi-fluted bur drill. This procedure utilizes four tapered flutes at a negative rake angle to create a layer of compact, dense bone surrounding the wall of the osteotomy. This densifying bur progressively increases the diameter as it is moved deeper into the bone site, which controls the expansion process. This results in a favorable environment to place an implant, thereby achieving higher primary stability and faster bone ingrowth due to the proximity of the implant surface and surrounding host bone.[18] The process of osseointegration contributes to bone formation on the implant surface and leads to implant secondary stability between bone and dental implant. In areas of low bone density, such as the maxillary posterior region, the insufficient bone available could affect the histomorphometric parameters such as % bone-implant contact (BIC) and % bone volume (BV) negatively, thereby affecting primary and secondary implant stability. A layer of increased bone mineral density has been shown by imaging around the periphery of osteotomies using OD. The increase in bone density achieved by OD has been shown to have a potentiating effect on secondary stability.[19] The graphical representation of these results is shown in graphs I and II.

4.2 **Crestal bone level changes:**

According to Lazarra RJ[20] bone loss in the immediate postoperative period occurs primarily because of two phenomena:

- Regional Acceleratory Phenomenon – A gradient of localized remodeling disseminating through the bone adjacent to any invasive bone procedure.
- Establishment of the biological width around implants – The concept of biological width in recent years has also been applied to osseointegrated implants because soft tissues around dental implants exhibit relatively constant dimensions. The biological width comprises the zone of supracrestal connective tissue of approximately 1mm and epithelial structures which measure about 2mm.

Similar findings were reported by **Cochran DL[21] et al** and **Enkling N[22]** who demonstrated that clinically significant remodeling of the marginal bone takes place resulting in bone level alteration after implant placement.

A separate study by **Trisi P[8] et al** assessed the efficacy of the osseodensification procedure to improve bone ridge width, density, and implant secondary stability. They conducted a biomechanical and histological analysis after inserting 20 implants in the iliac crest of 2 sheep and using the conventional drill for implants on one side as control and the Osseodensification technique for implants on the other side as a test group. In the test group, the authors reported a significant gain in ridge width and volume of bone. This increases the density of bone in the OD site which was said to be noticeable in most coronal implant sites where the trabeculae of bone were thickened due to incorporation of autogenous bone throughout healing. Hence there is no significant change in the crestal bone level of the implant on both mesial and distal aspects with the osseodensification technique within 3 months (Tables 3 and 4).

On the other hand, **Kong L et al[23]** reported different stress distribution patterns and concluded that OD is not useful in compact bone and might have a different effect in soft cancellous bone and that the effects of different thread designs are evidently noticed in cancellous, rather than compact bone. This can be explained by the fact that soft bone has wider marrow spaces between the bone trabeculae, allowing for bone compaction, rather than compact bone which the OD would lead to lateral compression that exceeds the viscoelastic limit of the thick and dense bone trabeculae, with subsequent damage and a weaker bone implant interface. **Bischof M[24] et al** who studied the factors affecting the dental implants' primary stability, similarly, reported and suggested that it is not the diameter or length of the implant or the implant thread depth that affects primary stability, but the bone type in the mandible or the maxilla.

In our study radiographs were taken with a radiographic lead grid to assess the crestal bone level changes which were measured in mm from a fixed reference point i.e., the first thread of the implant which is permanently visible and easy to locate on all radiographs. The second reference point was the bone-implant contact at the crestal bone level. Bone Implant Contact determines the degreeof osseointegration by tabulating the bone percentage of bone contact over the entire relevant implant surface perimeter. The measurement was done by dropping perpendicular from the reference lines to the bone levels with the use of radiovisiography using ADSTRA imaging RVG software. We measured the level of crestal bone on both mesial and distal aspects.

4.3 **Clinical significance:**

According to the results obtained in the current study, the primary stability of the implants can be achieved higher than 70 on the ISQ scale with both conventional and osseodensification techniques; even in the maxillary posterior region of the jaw where the bone is of D3 or D4 quality usually. Hence immediate nonfunctional loading of implants can be considered. The results of the present study are in accordance with the studies conducted by Malo and colleagues, Degidi and Piattelli, Calandriello et al, Romanos et al, and Ghanavati et al who found that immediately loaded implants too increased the osseointegration as did delayed loaded implants. But as shown in terms of both primary and secondary stability of implants, the osseodensification technique proves better than the conventional one. Hence, the osseodensification technique is to be followed clinically for the replacement of missing teeth with implant-supported prosthesis.

The crestal bone loss between 0-3 months' time interval was not significant for the osseodensification technique, but it was highly significant with the conventional technique with immediate loading. Hence for the long-term success of implants in the region of poor bone quality osseodensification technique is to be chosen over the conventional technique (Graph 2).

The present study showed that immediate loading of dental implants with the provisionals kept out of all centric and eccentric contacts can be successfully considered for replacing maxillary posterior teeth if all the criteria for immediate loading are fulfilled.

5. CONCLUSION

1. The mean stability of immediately loaded implants placed with the osseodensification technique was higher as compared to the conventional technique when measured both at the time of immediate implant loading and after 3 months, with a highly significant statistical difference.

2. Immediate-loaded implants placed with the osseodensification technique show better primary and secondary stability and, hence can be considered superior for immediate loading than those placed with conventional technique.

3. There was a highly significant mean difference in bone levels on both mesial and distal aspects of immediately loaded implants placed with conventional technique within 0–3-month intervals.

4. There was no significant mean difference in bone levels on both mesial and distal aspects of immediately loaded implants placed with osseodensification technique within 0-3 months intervals.

5. The osseodensification technique turns out to be the superior osteotomy preparation technique to the conventional one in terms of stability and crestal bone loss in immediately loaded dental implants placed in the maxillary posterior region.

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