"ASSESSMENT OF BONE DENSITY AT PERI IMPLANT SITE USING OSTEOTOMY AND OSSEODENSIFICATION TECHNIQUE"

A dissertation submitted to

BABU BANARASI DAS (BBD) UNIVERSITY

in partial fulfillment of the requirement for the degree

of

MASTERS IN DENTAL SURGERY

In

PROSTHODONTICS AND CROWN & BRIDGE

By

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DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation entitled **"ASSESSMENT OF BONE DENSITY AT PERI IMPLANT SITE USING OSTEOTOMY AND OSSEODENSIFICATION TECHNIQUE"** is a bonafide and genuine research work carried out by me under the guidance of ***Prof. (Dr.) Amrit Tandan***, Professor, Department of Prosthodontics Crown and Bridge, Babu Banarasi Das College of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

Date
Place

Dr Krishna priyadarsharn

CERTIFICATE BY THE GUIDE

This is to certify that the dissertation entitled **"ASSESSMENT OF BONE DENSITY AT PERI IMPLANT SITE USING OSTEOTOMY AND OSSEODENSIFICATION TECHNIQUE"** is a bonafide work done by **Dr Krishna Priyadarshani,** under my direct supervision and guidance in partial fulfillment of the requirement for the degree of M.D.S. in Prosthodontics Crown and Bridge.

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This is to certify that the dissertation entitled **"ASSESSMENT OF BONE DENSITY AT PERI IMPLANT SITE USING OSTEOTOMY AND OSSEODENSIFICATION TECHNIQUE"** is a bonafide work done by **Dr. Krishna Priyadarshani,** under direct supervision and guidance of **Prof. (Dr.) Swati Gupta,** Professor and Head, Department of Prosthodontics Crown and Bridge, Babu Banarasi Das College Of Dental Sciences, Babu Banarasi Das University, Lucknow, Uttar Pradesh.

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" Some of your greatest blessings , come with patience "

- Warren Wiersbe

To begin, I'd want to express my sincerest love and obedience to ***the Almighty***, who is the mastermind behind the entire creation's performance and in whose presence the entire living and inanimate cosmos prostrates in supplication and prayer.

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Dr Krishna Priyadarshani

LIST OF GRAPHS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ANNEXURES

Abstract

Background of the study

Low bone density can impair bone-to-implant contact and impede osseointegration. Various osteotomy procedures and drilling processes have been used to increase stability in low-density bone. The osseodensification technique uses densifying burs to produce low plastic deformation, which preserves the bone and enhances the host site.

Aim and Objectives:

The aim of the study is to evaluate and compare the changes in bone density occurring pre and post implants placement with osteotomy and osseodensification technique.
Objectives of the study are to evaluate the bone density of the site before implant placement and then after implant placement at intervals of one and three months.

Material and Methodology

40 implants were placed in low bone density regions (Misch's D3 & D4) which were divided into 2 groups.

Test group – osteotomy technique (20 implants)

Control group – osseodensification technique (20 patients)

CBCTs were done one month and three months following implant implantation to assess the change in bone mineral density (Hounsfield units).

Results

The difference in mean values at one month and three months for osseodensification (OD) and osteotomy (OS) were 31.83 (OD), 83.85 (OD). 2.45 (OS), and 33.26 (OS), respectively. The results show that when an implant is implanted by osseodensification surgery rather than an osteotomy, bone density increases more.

Conclusion

The study concluded that the osseodensification approach increased bone mineral density in the poor bone density region when compared to the standard osteotomy procedure.

Key words: Osteotomy, Osseodensification, bone mineral density, densah burs

The issue of missing teeth has plagued humanity since time immemorial. Better tooth replacement options emerged as material sciences advanced and our understanding of occlusion and the gnathostomatic system improved. All of the advancements were focused with the three major aims of comfort, function, and esthetics, and any advancement that aided in these goals was promoted.

Dental implants are used to replace missing teeth and to hold dental prostheses in partially and completely edentulous arches. Dental implants have transformed dental rehabilitation. Osseointegration is the most essential requirement for effective implant treatment. Inadequate bone quality and quantity pose a challenge to achieving stability, which is a crucial factor in successful osseointegration. Osseointegration was originally defined as the direct structural and functional connection between ordered living bone and the surface of a load-bearing implant. The implant is said to be osseointegrated when there is no progressive relative movement between it and the bone with which it is in direct contact. Although the term "osseointegration" was originally applied to titanium metallic implants, it is now used to describe any biomaterial that has the ability to osseointegrate.[51]

Brånemark, discovered osseointegration in 1962 and coined the term in 1977, defining it as "the process resulting in direct structural and functional connection between ordered, living bone and the surface of a (load-bearing) implant," which provides the foundation for desired dental implant functioning.[1] Direct microscopic bone-to-implant contact and the quantity and quality of the histologic bone structure at the implant interface, both of which are strongly correlated with bone mineral density, are two frequently reported osseointegration factors.

Conventional implant site preparation techniques are subtractive in nature, employing a clockwise rotating drill of increasing diameter with heavy irrigation to excavate the bone and prepare the implant bed.

Dr Salah Huwais (2013) developed osseodensification, a non-subtractive bone technique characterised by low plastic deformation of bone caused by rolling and sliding contact with specially designed burs, named as Densah burs, which has a negative rake angle that precisely cuts bone in the clockwise direction and densifies

bone in a noncutting counter-clockwise direction towards the wall.[38] It enables the implant to engage more intimately with the osteotomy site, increasing primary stability.

Osseodensification provides advantages of both osteotomes combining the speed along with improved tactile control of the drills during osteotomy. Standard drills excavate bone during implant osteotomy, while osteotomes tend to induce fractures of the trabeculae that requiring long remodelling time and delayed secondary implant stability. Osseodensification, on the other hand, preserves bone bulk, so bone tissue is compacted and autografted in an outwardly expanding direction to form the osteotomy. To achieve osteotomy expansion, bone densification, and indirect sinus lift, as well as bone expansion at various sites of compromised bone quality, the Osseodensification technique employs universally compatible drills, densah burs. The rationale behind this process is that by densifying the bone in direct contact with the implant, a denser bone interface and a significantly higher bone-to-implant contact ratio are formed, amplifying mechanical engagement and reducing micro-motion between the implant and the implant bed's bone walls. The pumping motion generates a rate-dependent stress, which causes a rate-dependent strain and allows the saline solution to exert outward pressure on the osteotomy walls. This combination promotes bone plasticity and bone expansion.

The current study compares the bone mineral density at the peri-implant site before and after implant placement with osteotomy to the osseodensification technique.

AIM

The aim of the study is to evaluate and compare the changes in bone density occurring pre and post implants placement with osteotomy and Osseodensification technique.

OBJECTIVES

1. To evaluate the bone density of the site before implant placement.

2. To evaluate the bone density of peri implant site after implant placement by osteotomy technique after one month

3. To evaluate the bone density of peri implant site after implant placement by osteotomy technique after three month

4. To evaluate the bone density of the peri implant site after one month of placement of implant by osseodensification technique.

5. To evaluate the bone density of the peri implant site after three month of placement of implant by osseodensification technique

6. To compare the bone density of peri implant site before and after implant placement via osteotomy technique.

7. To compare the bone density of peri implant site before and after implant placement via osseodensification technique.

8. To compare the difference between the bone density obtained by osteotomy technique and osseodensification technique.

Brånemark PI, Briene U, Adell R, Hansson O, Lindstrom , Ohlsson (1969)[1] did an experimental investigation on dogs to find out factors which are liable to influence the stability of anchorage of Ti implants. Arcuated implants were anchored by a screw passing transversely through the jaw. It was concluded that several factors determined the fate of implant like implants size, atraumatic restoration, primary fixture closure, loading of implant.

Adell R, Lekholm U, Rockler B, Branemark PI (1981)[2] conducted a 15 year long longitudinal study to find out osseointegration can only be achieved by a general surgical procedure and long healing period and uniform stress distribution in functional state. Once the implants were placed the radiographic examinations were done after one week, 6 months, 12 months postoperatively. It was concluded that osseintegration creates a direct and intimate contact between the vital bone and threaded Ti fixtures.

Albrektsson T, Brånemark PI, Hansson HA, Lindström J. (1981)[3] conducted a study on Osseointegrated titanium implants and the requirements for ensuring a long-lasting, direct bone-to-implant anchorage in man. The SEM analysis revealed that titanium and bone have a very close spatial relationship. TEM revealed a dense lamellae type bone with well-organized concentric lamellae. They came to the conclusion that osseointegration is a dependable cement-free bone harbour for permanent prosthetic tissue substitutes.

Jaffin R and Berman C (1991)[4] in clinical study spanning over 5years observed a failure rate of implant placement, following Branemark's protocol, of 35% in type 4 bone while only 3% of implants failed in type 1, 2, and 3 bone. The authors concluded that, because type 4 bone has a high failure rate, presurgical assessment of type 4 bone might improve treatment predictability.

Zarb G and Schmitt A (1993)[5] studied the clinical effectiveness of osseointegrated dental implants for single tooth replacement. Thirty-two patients

with 40 single-tooth spaces were treated with 40 implants. Twelve implants were placed in the mandible (all in the posterior zone). It was observed that after loaded service periods ranging from 1.4 to 6.6 years (mean 2.9 years), all implants remain in function and have ensured successful prosthodontic treatment.

Zarb GA, Schmitt A (1993)[6] studied the longitudinal clinical effectiveness of osseointegrated dental implants in anterior partially edentulous patients. Ninety-four implants were placed into 34 edentulous areas in 30 partially edentulous patients. It was observed that there was an average success rate of 91.5% which was sufficient to ensure a 100% resolution of the selected patients' maladaptive prosthodontic experiences.

Rosenquist B et al (1996)[7] conducted a study in 51 patients, a total of 109 implants were placed into extraction sockets immediately following extraction. The follow-up period varied between 1 to 67 months. Osseointegration was determined by clinical stability, lack of symptoms, and lack of peri-implant pathology based on radiographic examination. When certain standards are followed, rapid implantation of implants into extraction sockets is proved to be a safe and predictable technique.

Brägger U, Hämmerle CH, Lang NP (1996)[8] conducted a study to compare the peri-implant mucosal conditions 1 year after immediate transmucosal implant placement without or in combination with guided tissue regeneration. On probing, the immediate implants showed a reduced frequency of site bleeding. The study found that immediate oral implants are a viable therapy option with a high degree of predictability.

Brugnami F, Then PR, Moroi H, Leone CW (1996)[9] conducted a study evaluated new bone formation in human extraction sockets treated with demineralized freeze-dried bone allografts (DFDBA) and cell occlusive membranes. Hard tissue biopsies of 7 sites in 6 patients were obtained 14 weeks to

13 months following extraction and grafting. I was found out that commercially available DFDBA has the potential to function physically as a nidus for appositional new bone growth in alveolar sockets following tooth extraction.

Meredith N (1998)[10] discussed the parameters necessary to monitor successful implant placement. They discussed various techniques for measuring implant stability and osseointegration, such as cutting resistance, removal torque values, Periotest and Dental Fine Tester. RFA has the potential to predict implant outcome since it provides crucial information about stability throughout both insertion and function.

Mayfield LJ, Lang NP, Karring T, Lindhe J (1999)[11] compared immediate implant placement (IIP), delayed and late submerged and transmucosal implants. They discovered that whether using an IIP or a delayed placement procedure, the implant survival rate is identical. They came to the conclusion that IIP had a number of advantages versus delayed installation, including improved healing without flap advancement and reduced treatment duration, surgical procedures, expense, and pain.

Martinez H et al (2000)[12] proposed various protocols to achieve optimal implant stability in low density bone sites. They suggested the use of CT for qualitative and quantitative analysis of the residual bone and RFA for recording the primary and secondary implant stability.

Morris HE, Ochi S, Crum P, Orenstein I, Plezia R (2003)[13] studied the influence of bone density on implant stability. Implants were placed into 4 blocks, selected to simulate the various bone densities. They discovered that the Perio test values (PTVs) of implants in type 4 bone were significantly less negative than those of other bone densities implying that the bone-implant complex does not improve in any significant way and may, in fact, deteriorate slightly during long-term functional loading.

Fugazzatto et al (2004)[14] used a combination of osseous coagulum collected during preparation and freeze-dried bone allograft for immediate implant insertion and loading. The outcome was promising, with a clinically immobile implant and healthy surrounding soft tissue six months after surgery; no post-operative gingival recession; no probing depth surpassing three millimetres; no bleeding on probing; and no sensitivity to pressure.

O'Sullivan D, Sennerby L, Jagger D, Meredith N(2004)[15] compared two methods of enhancing implant primary stability in type IV bone. 1) Standard Branemark System Implants inserted without using a surgical tap to prepare a threaded channel in the bone to enhance primary stability and 2) Branemark MK IV implants inserted according to the manufacturer's instruction. A statistically significant lower RFA values were observed in both the groups in type 4 bone. It was concluded that the techniques used to maximize primary implant stability in type 4 bones were unable to achieve the desired results and success.

Buchter A et al (2005)[16] compared the osseointegration and biomechanical behavior of implants placed by osteotome technique (group B) with the conventional implant site preparation technique (group A) in an animal model. They concluded that there is a decrease in implant stability with osteotome technique mainly due to micro-fractures in peri-implant bone.

Miyamoto I, Tsuboi Y, Wada E, Suwa H, Iizuka T (2005)[17] evaluated role of regional bone structure on the dental implant stability at the time of surgery. CT scans were obtained to measure the cortical bone thickness of cortical bone at the sites of implant placement. The average ISQ value of the implants placed in mandible was higher than those placed in maxilla. They concluded that cortical bone thickness is extremely important for implants' stability and success.

Beer A, Gahleitner A, Holm A, Birkfellner W, Homolka P. (2006)[18] conducted a study on preparation technique for screw-type implants assessed the correlation

1. Materials and Equipment

Instruments needed during surgical procedure :

- Mouth mirror [API India]
- Explorer [API India]
- Tweezer [API India]
- Lidocaine topical aerosol
- Local anesthesia (2% Lignocaine hydrochlroide with adrenaline 1:80000)
- Normal saline (0.9%)
- Betadine 10% solution
- Bard parker blades (no- 11,15)
- Periosteal elevator - Molts
- Atraumatic Adson tissue holding forcep.
- Disposable syring
- Dental Implant system (Adin implant system, Taiwan/ Bioline implant)
- Physiodispenser (NSK)
- Implant hand piece
- Conventional implant placement drill kit
- Densah burs (Versah, Jackson MI USA) One size smaller than the implants used
- Surgical needle (ETHICON ™)
- Sutures (Vicryl # 3-0,4-0 absorbable sutures)
- Needle holder (API)
- Dean's surgical scissors (straight and curved)
- Suction tips

2. Place of the study where it is conducted

The study was conducted in the Department of Prosthodontics and Crown and Bridge, Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh.

3. Study subjects

Study was conducted in complete or partially edentulous patients desiring for the replacement of missing teeth, in Lucknow, Uttar Pradesh

11.4. Study Sample and size

Sample size- 40

Control group – 20 implants placement with osteotomy technique

Test group – 20 implants placement with osseodensification technique.

11.5. Eligibility Criteria:

Inclusion criteria:

- Patients who were conscious of their oral health and were willing to undergo restoration with dental implants.
- Patients with partially edentulous dentition
- Healthy patients with no systemic manifestations (ASA-I)
- Both males and females
- Age group- 18-60 year
- Proper inter occlusal space
- Bone type – D3 and D4 (Misch)
- Sufficient regenerated gingiva
- Good oral hygiene.

Exclusion Criteria:

- Patient who were not willing for the treatment
- Poor periodontal condition
- Parafunctional habits
- Inadequate inter-ridge distance
- Insufficient bone for implant therapy
- Heavy smokers
- Patient going through radiotherapy.

6. Sampling method

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation. The level of the significance for the present study was fixed at 5%.

The intergroup comparison for the difference of mean scores between independent groups was done using the independent t test

The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables. The data were found to be homogeneous and normally distributed. Mean and standard deviation (SD) were computed for each variable

7. Study design:

In this study the patients who were enrolled were selected considering their medical and dental history their current general and oral health statuses and the mentioned inclusion exclusion criteria.

METHODOLOGY

Case history:

A thorough medical history was taken, including whether the patient had any major systemic diseases (uncontrolled diabetes, hemophilia, hypertension, myocardial infarction, etc.) and any previous drug or food allergies.

A detailed dental history was taken, including previous restorative, periodontal, and endodontic treatments, reasons for tooth loss, and experience with orthodontic appliances and dental prostheses.

Lab investigation :

It was mandatory for all the patients as it helps in developing the treatment plan for the surgery and post-operative care.

- Routine blood examination along with HbsAg, HIV, HbA1c
- Fasting blood sugar

Procedure :

- For analysis of the edentulous space where implant was planned to be placed included the following procedure:
- Mounting of the diagnostic cast of the maxilla and the mandible, to assess the inter-arch space was done to obtain an idea about the space available for the placement of the crown over the implant.
- The mesio-distal and bucco-lingual dimension were measure over the edentulous space on the cast to have a tentative about the width of the bone available.

Pre surgical records:

1. Intraoral examinations were done and diagnostic records (panoramic radiograph, periapical radiograph, and diagnostic casts) were obtained before surgery for treatment planning.
2. **Preoperative CBCT** was taken to determine the appropriate width and length of the proposed implant and to ensure the average bone density was suitable for implant placement.

CBCT was used to accurately assess the available bone volume for implant placement in three dimensions (3D). It helps to accurately assess the bone volume of each implant site, the bone mineral density at the peri implant site, as well as the ridge angulations by loading CBCT data into specific software (Invivo ™ 5 Software, Anatomage Inc, CA, USA.).

To assess the effect of type of technique used to place the implants on bone density, a base line measurement of bone mineral density was recorded from the buccal and lingual wall, to use as a comparative parameter for both the groups.

Subjects were divided under two groups:

GROUPS	Bone density at peri implant site		
	PRE OPERATIVE	POST OPERATIVE	
CONTROL GROUP: OSTEOTOMY	-	After 1 month	After 3 months
TEST GROUP: OSSEODENSIFICATION	-	After 1 months	After 3 months

Surgical phase:

- Patients received Tab cefixime 200mg twice daily two days prior to surgery.
- Patient was seated then a sterile drape was used to cover the patient and asked to rinse mouth a 0.2% chlorhexidine digluconate solution for 2 minutes.
- Through nerve block and local infiltration, local anesthesia (2% Lignocaine hydrochloride with 1:80,000 adrenaline) was used to numb the surgical site.

Stage 1:

Implant placement

Initially the Surgical access was achieved by midcrestal incision that was placed with sulcular extensions to adjacent teeth on either side with a Bard-Parker blade no. 15.

Following the incision, the tissues were elevated away from the bone using periosteal elevator, providing clear means of access to the surgical site.

Usually, full-thickness mucoperiosteal flaps were elevated from these areas.

In the flapless group, to create the first penetration into the soft tissue, a soft tissue punch was employed. The diameter of the soft tissue punch was determined by the

implant that would be put following the osteotomy. Soft tissue punch available in three distinct sizes: 3 mm, 4 mm and 5 mm, was utilized in this investigation.

Control group : Conventional implant placement technique

- The implant osteotomy began with the pilot drill under copious amounts of saline irrigation.
- Drills were used in a clockwise sequence from smaller to larger diameters in compliance with the diameter of the implant to be placed at 800-1100 rpm.
- Angle was checked with the paralleling pin both clinically and radiographically.
- The osteotomy was then diametrically enlarged to desired width.
- After completion of the osteotomy the implant was carried from the packaging to the site using the implant mount provided by the manufacturer.
- It was then screwed in or tightened using the ratchet until a torque of 35Nm - 45Nm is obtained while screwing the implant and was followed by the cover screw placement.

Test group: osseodensification technique

- The implant site was prepared using the osseodensification Densah burs under profuse saline irrigation.
- First drill (pilot drill) is used up to the required length, drill will rotate in the clockwise direction at 800-1200rpm.
- The sequential using of the next drills at 800-1500rpm anti-clockwise which is the noncutting densifying mode in pumping motion to full depth till adequate diameter is reached.
- Then the implant was carried from the packaging to the site using the implant mount provided by the manufacturer.
- It was then screwed in or tightened using the ratchet as mentioned above.

Flap closure:

- In subjects where the flaps were raised after incision, the flaps were closed with interrupted suture with vicryl 3-0, (non absorbable) which were removed after 1 week of placement

Post-surgical phase:

- Instructions were be given to avoid rinsing, spitting, or touching the wound on the day of surgery, soft and cold diet for first 24 hours
- Chlorhexidine gluconate 0.12% oral mouthwash was prescribed 3-4 times / day for two weeks
- Antibiotics: Amoxyclav 625mg (Amoxycillin with clavulinic acid) was recommended every 12 hourly for 5 days
- NSAIDS:
  Cataflam tablet (Diclofenac potassium) – 50mg, eight hourly for 5 days
  Or ibuprofen 400-600mg 6-8 hourly for 5 days

Wound healing:

- Patient was called after 7-10 for follow up visit.
- The sutured wound was examined for signs and symptoms of infection including swelling, redness, hotness, pus discharge, and pain in addition to observation for any manifestations of wound healing disturbance, as wound dehiscence
- Sutures was removed after one week of surgery.

Stage 2:

- Patients were recalled after one month of implant placement and then after 3rd month for observing the bone density at peri implant site with the help of CBCT
- After healing period of 3-5 months, a second stage surgery was performed and healing abutments were placed.

- After 15 days of gingival collar placement, impression copings were placed and impressions were taken with closed tray impression.
- Impressions were sent to the dental lab for prosthesis fabrication.
- Thereafter, following coping try in, definitive restorations were cemented following the principles of implants protected occlusions.

ASSESMENT PARAMETERS:

Evaluation of bone density:

CBCT was taken at the following intervals:

1) Preoperative (in both groups)
   CBCT – to assess the bone quality and quantity

2) Post operative (in both groups)
   CBCT at 1 month of implant placement
   CBCT at 3 month of implant placement

- Bone quality was assessed by a taking cone beam computed tomographic (CBCT) images. A standard CBCT with standard exposure parameter was decided to evaluate the bone density.
- i-Cat CB500 CBCT machine using i-CAT VisionQ and Invivo5 ™ anatomage software were used for the study.
- The i-CAT visionQ software is used to measure interactive images for surgical implant planning and bone density.
- The i-CAT visionQ software is used to calculate bone density and plan surgical implants using interactive images. Basic 3D images with cross-sectional views are available, as are customizable visual display modes such as axial, panoramic, and cross-sectional views.
- Basic 3D images with cross-sectional views are available, as are a variety of visual display modes that can be customized, including axial, panoramic, and cross-sectional views.

- A region of interest was selected to measure the implant peripheral bone density in both control group and test group.
- The buccal and lingual walls from the crest of ridge were chosen at the site where implant was to be placed before implant placement.
- Bone mineral density was evaluated at intervals of 2mm, starting from the crest (0mm) then at 2mm and so on till 10mm in Hounsefield units(HU)
- After implant placement same parameters were used to determine the bone mineral density.
- Then the results were compared.

The obtained statistical data was tabulated and subjected to appropriate statistical analysis.

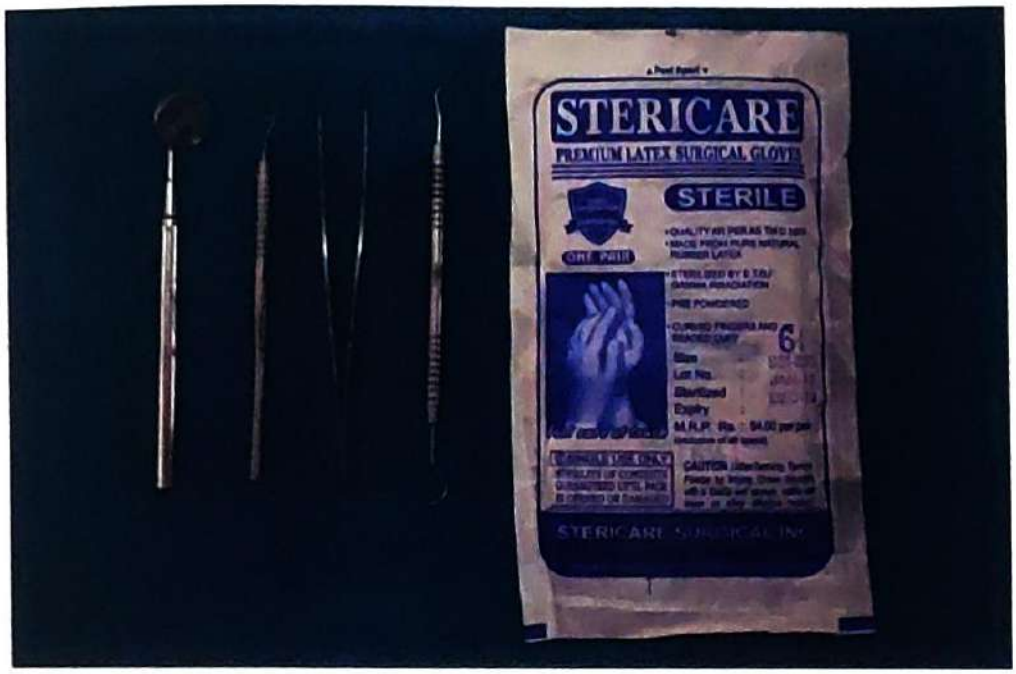


Fig 1. Diagnostic instruments

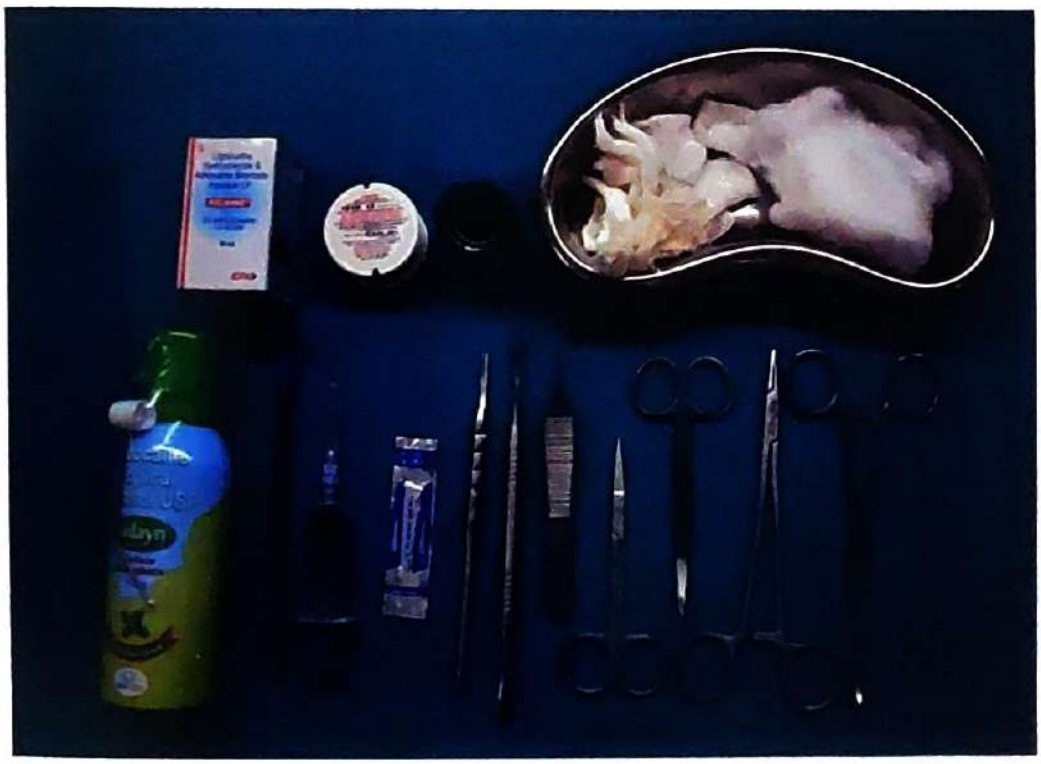


Fig. 2. Surgical instruments

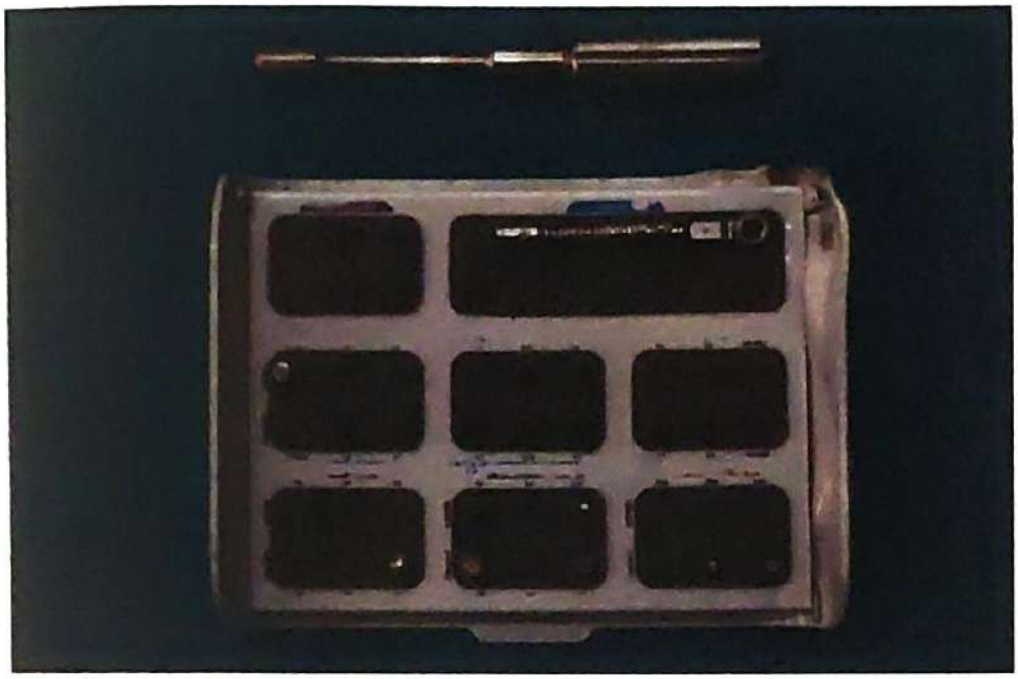


Fig. 5 Adin Surgical Implant Kit

Fig 6. Versah Kit with densification drills

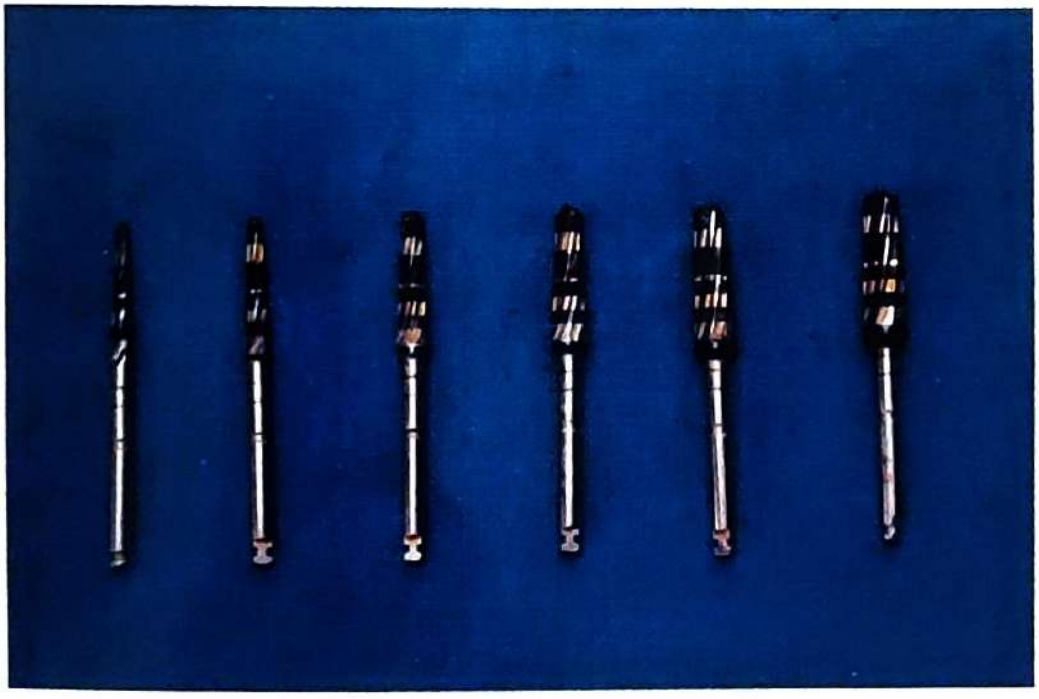


Fig 7. Sequential arrangement of densification drills

CBCT REPORTS

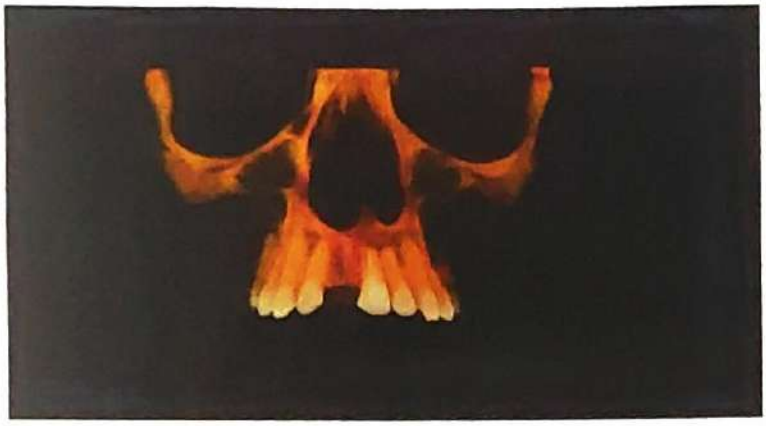


Fig 12. Pre operative CBCT wrt 11

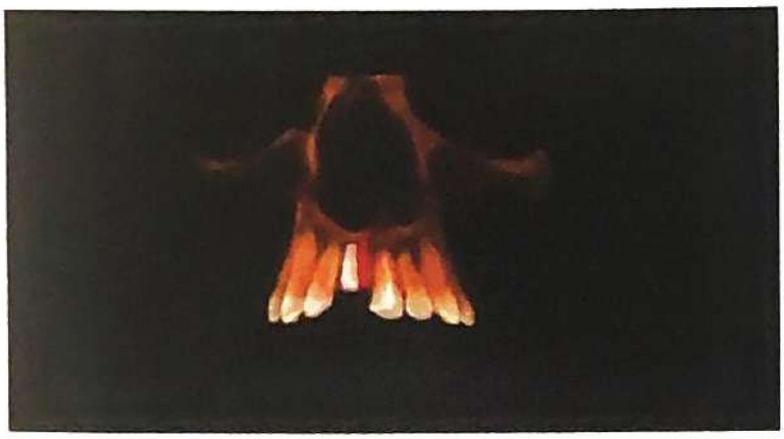


Fig 13. Post operative CBCT after implant placement at 1 month.

Fig 14. Measuring the bone density from the crest at intervals of 2mm

OSTEOTOMY TECHNIQUE

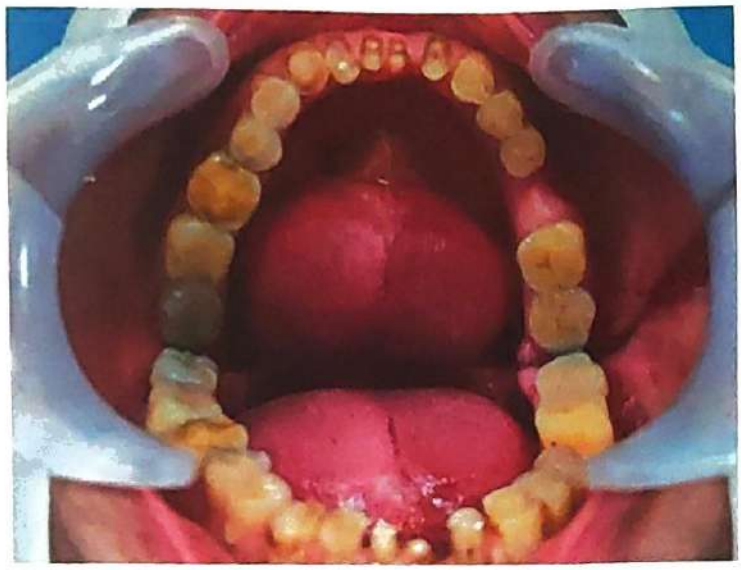


Fig.15 Preoperative Occlusal view

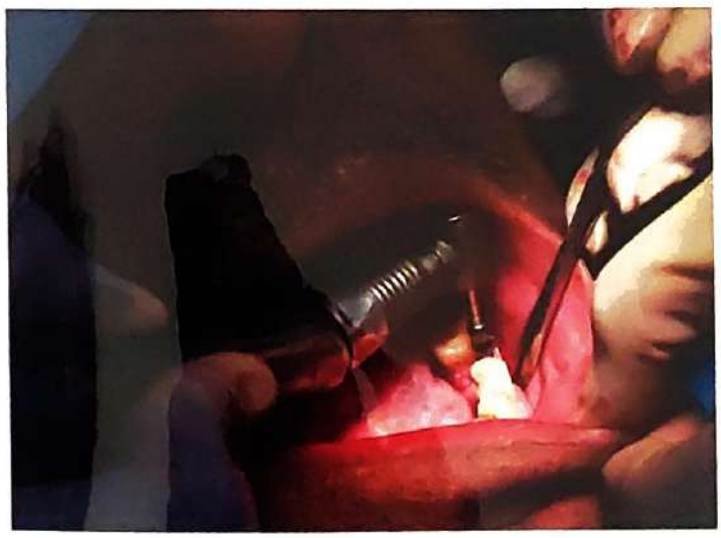


Fig.16 drilling with osteotomy bur

CBCT REPORTS

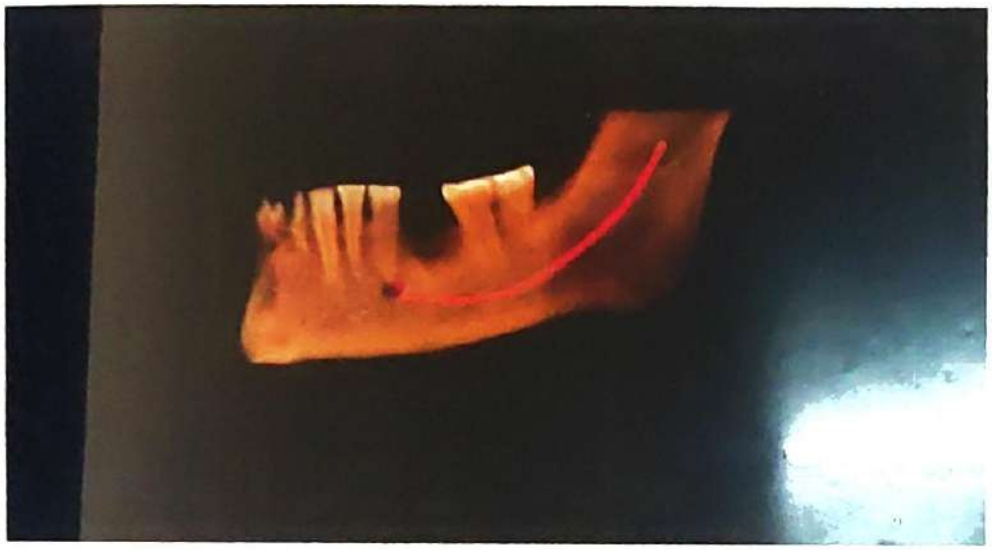
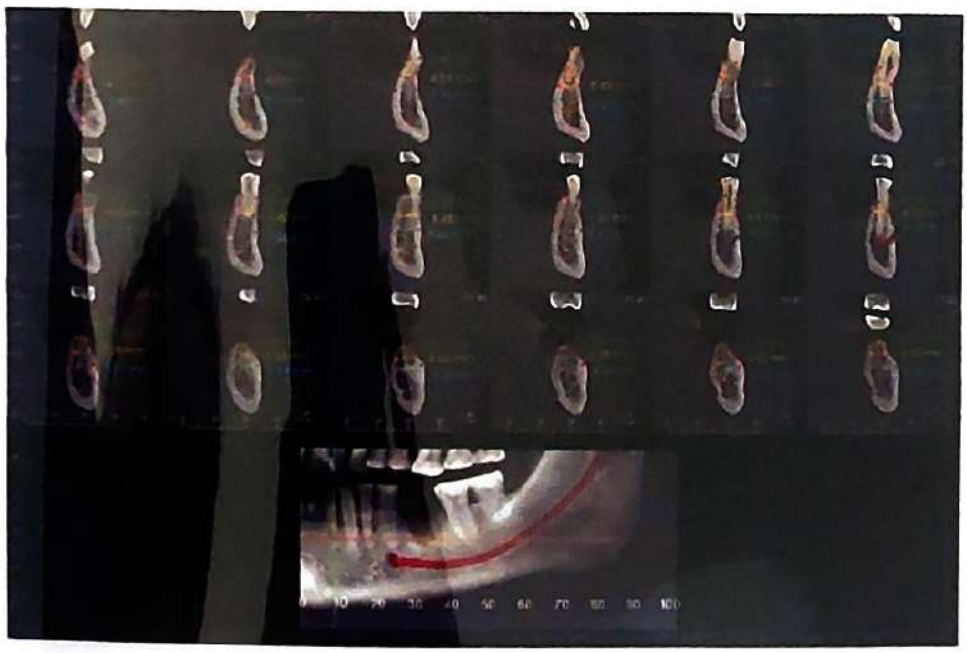


Fig 17. Pre-operative CBCT

a) locating the mandibular nerve



b) showing the cross section of the mandible at region of 36

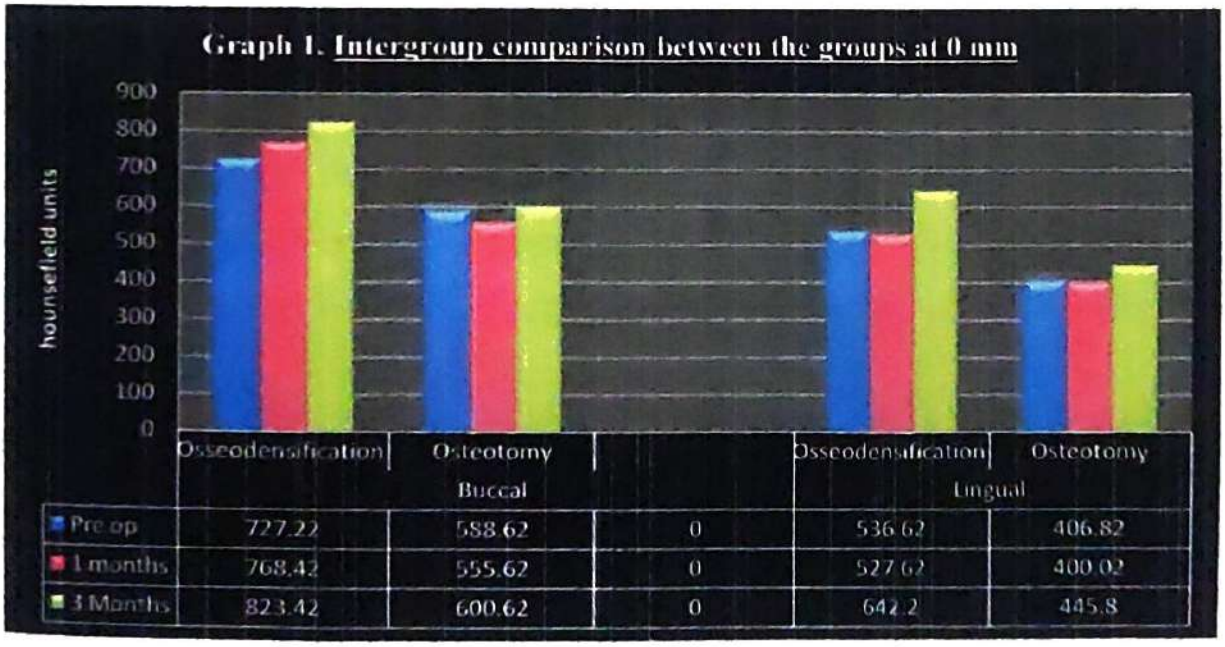
The present " in vivo study" was conducted in post graduate department of prosthodontics, BBDCODS, Lucknow in order to assess the bone density at peri implant site using osteotomy and osseodensification technique.

For this purpose, a total of 40 implants were placed in low bone density region, i.e. D3, D4 bone type according to Misch's classification. Subjects were randomly chosen for the control group and test group. 20 implants were placed in each group. Total of three CBCTs were taken of each implant site, one pre-operatively and another two at intervals of one and three months post operatively, for bone density evaluation at peri implant site. The buccal and lingual walls from the crest of ridge were chosen at the site where implant was to be placed before implant placement. Bone mineral density was evaluated at intervals of 2mm, starting from the crest (0mm) then at 2mm and so on till 10mm in Hounsefield units(HU)

GROUPS	**Bone density at peri implant site**		
	PRE OPERATIVE	POST OPERATIVE	
CONTROL GROUP: OSTEOTOMY	-	After 1 month	After 3 months
TEST GROUP: OSSEODENSIFICATION	-	After 1 months	After 3 months

Table 1. Intergroup comparison between the groups at 0 mm

	Group	Pre op	1 months	3 Months	Change at 1 month	Change at 3 month	%Change at 1 month	% Change at 3 month
Buccal	Osseodensification	727.22±196.51	768.42±93.99	823.42±72.803	41.20±184.46	-96.20±194.60	-13.15±38.59	-22.04±44.03
	Osteotomy	588.62±187.682	555.62±112.28	600.62±137.58	33.00±94.188	-12.00±87.46	2.80±14.37	-4.50±15.71
P value							0.411(Non-Sig)	0.426(Non-Sig)
Lingual	Osseodensification	536.62±234.13	527.62±204.07	642.20±138.18	9.00±44.19	105.60±240.76	0.03±5.77	-47.43±103.12
	Osteotomy	406.82±159.88	400.02±152.88	445.80±120.58	6.80±15.53	-39.00±53.59	1.07±4.40	-15.14±23.62
P value							0.754(Non-Sig)	0.556(Non-Sig)



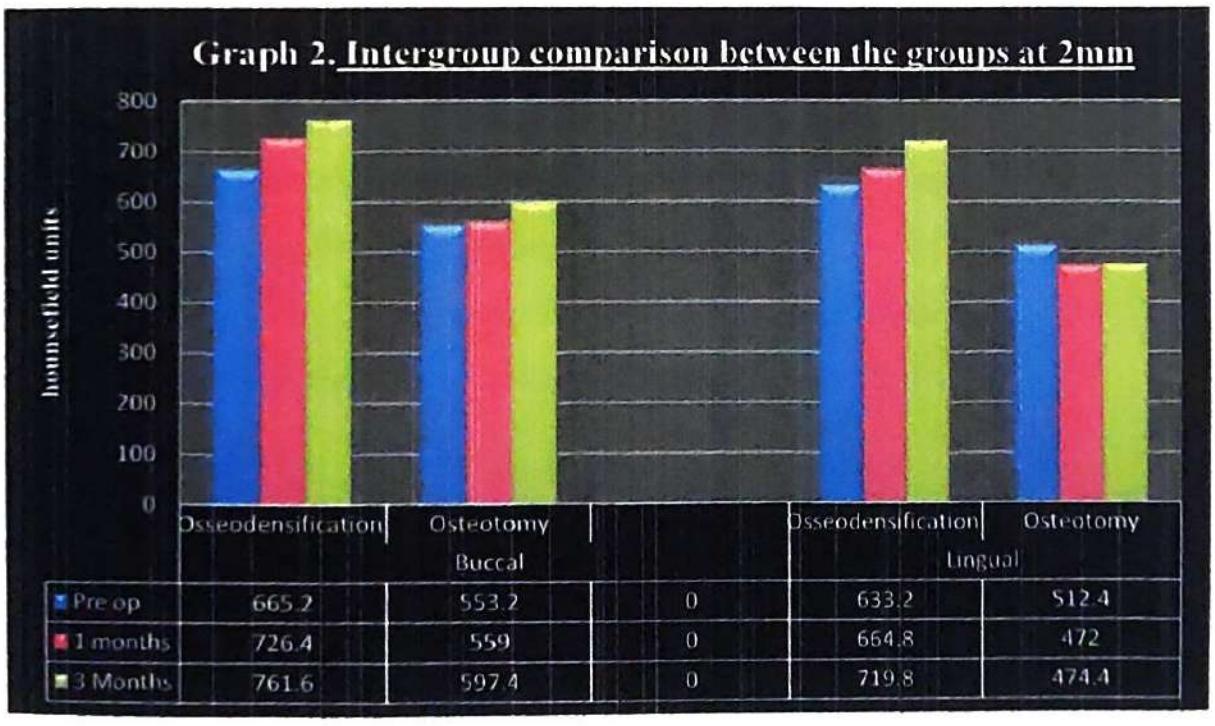
At the buccal side in the Osseodensification group the mean bone density measured at 0mm, at the pre treatment level was 727.22±196.51, at the 1 month time interval was 768.42±93.99 and at the 3 month time interval was 823.42±72.803. The percentage change at the 1 months was -13.15±38.59 and at the 3 months was -22.04±44.03. In the osteotomy group the mean bone density at the pre treatment level was 588.62±187.682 at the 1 month time interval was 555.62±112.28 and at the 3 month time interval was 600.62±137.58. The percentage change at the 1 months was 2.80±14.37 and at the 3 months was -4.50±15.71. The intergroup comparison between Osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

At the lingual side in the Osseo densification group the mean bone density at the pre treatment level was 536.62, at the 1 month time interval was 527.62±204.07 and at the 3 month time interval was 642.20±138.18. The percentage change at the 1 months was 0.03±5.77 and at the 3 months was -47.43±103.12In the osteotomy group. The mean bone density at the pre treatment level was 406.82±159.88 at the 1 month time interval was 400.02±152.88 and at the 3 month time interval was 445.80±120.58. The percentage change at the 1 months was 1.07±4.40 and at the 3 months was -15.14±23.62. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

Table 2. Intergroup comparison between the groups at 2mm

	Group	Pre op	1 months	3 Months	Change at 1 month	Change at 3 month	%Change at 1 month	%Change at 3 month
Buccal	Osseodensification	665.20±176.32	726.40±106.84	761.60±101.92	61.20±118.73	96.40±96.422	-14.67±30.74	-19.60±26.78
	Osteotomy	553.20±150.67	559.00±123.19	597.40±141.18	-5.80±90.862	44.20±107.30	-2.96±18,33	-10.08±23.06
P value							0.207 (Non-Sig)	0.485 (Non-Sig)
Lingual	Osseodensification	633.20±189.03	664.80±155.35	719.80±116.06	31.60±37.680	86.60±107.49	-7.18±10.24	-19.55±29.43
	Osteotomy	512.40±204.69	472.00±42.15	474.40±38.668	40.40±170.05	38.00±171.98	.87±23.08	0.34±22.56
P value							0.495 (Non-Sig)	0.584 (Non-Sig)

Graph 2. Intergroup comparison between the groups at 2mm



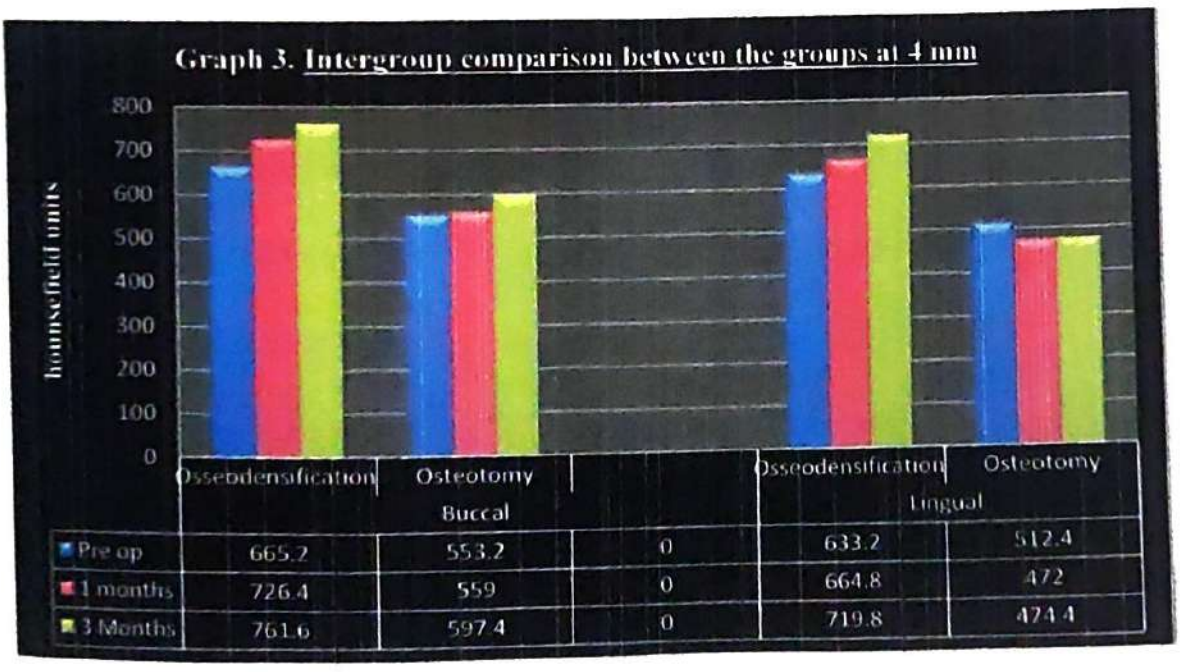
At the buccal side in the Osseodensification group the mean bone density at the pretreatment level was 665.20±176.32, at the 1 month time interval was 726.40±106.84 and at the 3 month time interval was 761.60±101.92. The percentage change at the 1 months was -14.67±30.74 and at the 3 months was -19.60±26.78. In the osteotomy group. The mean bone density in osteotomy site at the pretreatment level was 553.20±150.67 at the 1 month time interval was 559.00±123.19 and at the 3 month time interval was 597.40±141.18. The percentage change at the 1 months was -2.96±18,33 and at the 3 months was -10.08±23.06. The intergroup comparison between Osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05

At the lingual side in the Osseo densification group the mean bone density at the pre treatment level was 633.20±189.03, at the 1 month time interval was 664.80±155.35 and at the 3 month time interval was 719.80±116.06. The percentage change at the 1 months was -7.18±10.24 and at the 3 months was -19.55±29.43 In the osteotomy group The mean bone density at the pre treatment level was 512.40±204.69 at the 1 month time interval was 472.00±42.15 and at the 3 month time interval was 474.40±38.668 The percentage change at the 1 months was 0.87±23.08 and at the 3 months was 0.34±22.56. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

Table 3. Intergroup comparison between the groups at 4 mm

	Group	Pre op	1 months	3 Months	Change at 1 month	Change at 3 month	Percentage Change at 1 month	Percentage Change at 3 month
Buccal	Osseodensification	725.40±216.25	803.40±44.32	824.00±93.91	-78.00±210.43	-98.60±159.03	-22.94±54.10	-23.27±44.16
	Osteotomy	478.60±121.23	502.20±131.17	571.00±107.74	-23.60±100.27	-92.40±193.31	-6.75±26.20	-23.19±32.61
P value							0.594 (Non-Sig)	0.998 (Non-Sig)
Lingual	Osseodensification	656.80±201.34	644.80±206.99	78120±143.40	12.00±57.02	-124.40±157.47	1.90±8.62	-25.39±34.73
	Osteotomy	469.40±53.46	452.00±70.06	507.80±92.81	17.40±32.73	-38.40±88.53	3.86±7.03	-8.54±19.02
P value							0.704 (Non-Sig)	0.377 (Non-Sig)

Graph 3. Intergroup comparison between the groups at 4 mm

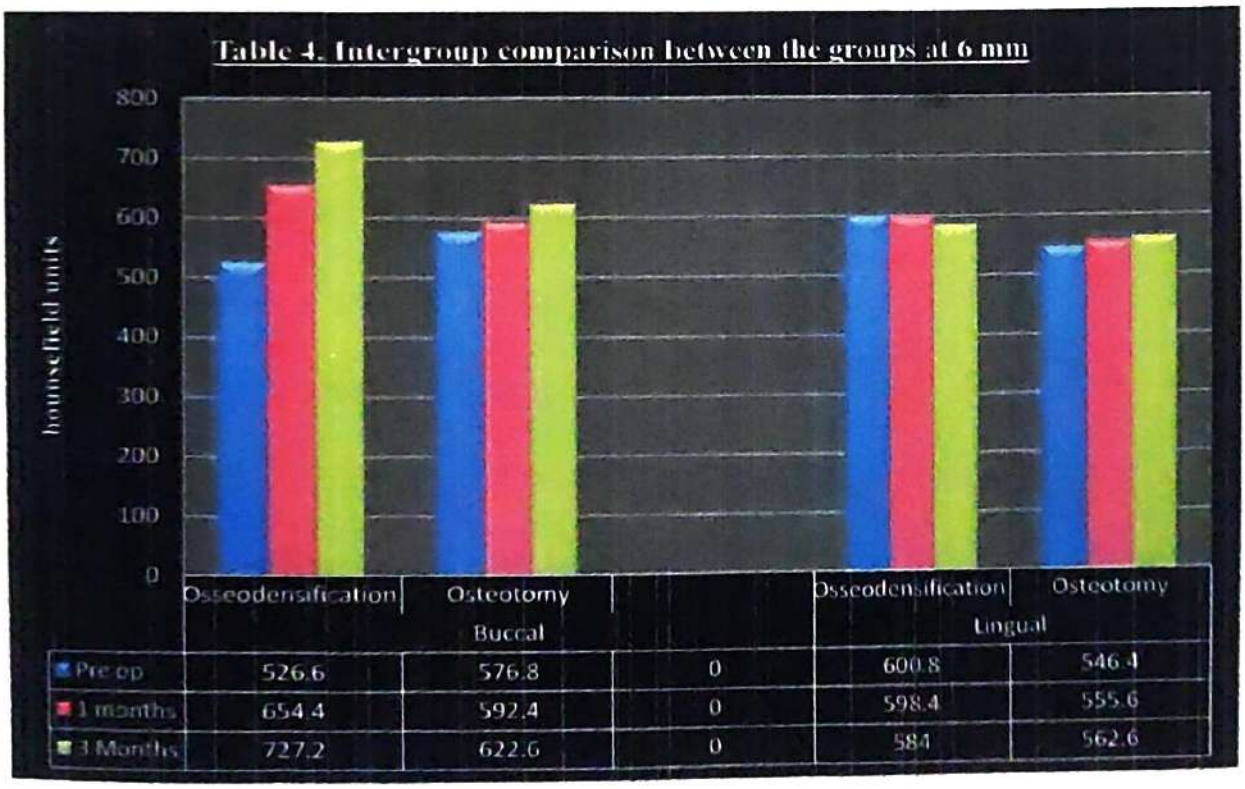


At the buccal side in the Osseo densification group the mean bone density at the pre treatment level was 725.40±216.25, at the 1 month time interval was 803.40±44.32 and at the 3 month time interval was 824.00±93.91. The percentage change at the 1 months was -22.94±54.10 and at the 3 months was -23.27±44.16 In the osteotomy group The mean bone density at the pre treatment level was 478.60±121.23at the 1 month time interval was 502.20±131.17 and at the 3 month time interval was 571.00±107.74 The percentage change at the 1 months was -6.75±26.20 and at the 3 months was -23.19±32.61. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05

At the lingual side in the Osseo densification group the mean bone density at the pre treatment level was 656.80±201.34, at the 1 month time interval was 644.80±206.99 and at the 3 month time interval was 78120±143.40. The percentage change at the 1 months was 1.90±8.62 and at the 3 months was -25.39±34.73 In the osteotomy group The mean bone density at the pre treatment level was 469.40±53.46at the 1 month time interval was 452.00±70.06 and at the 3 month time interval was 507.80±92.81 The percentage change at the 1 months was3.86±7.03 and at the 3 months was -8.54±19.02. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

Table 4. Intergroup comparison between the groups at 6 mm

	Group	Pre op	1 months	3 Months	Change at 1 month	Change at 3 month	Percentage Change at 1 month	Percentage Change at 3 month
Buccal	Osseodensification	526.60±110.30	654.40±102.41	727.20±89.14	127.80±182.41	200.60±187.52	-31.37±49.34	-46.22±51.40
	Osteotomy	576.80±183.72	592.40±158.73	622.60±123.29	-15.60±140.92	-45.80±131.25	-7.07±33.18	-13.47±31.49
P value							0.398 (Non-Sig)	0.259 (Non-Sig)
Lingual	Osseodensification	600.80±133.85	598.40±148.44	584.00±110.48	2.40±99.28	16.80±135.01	-.30±14.80	-.24±23.16
	Osteotomy	546.40±222.22	555.60±193.73	562.60±121.99	-9.20±86.04	-16.20±145.66	-4.81±13.74	-12.70±31.66
P value							0.637 (Non-Sig)	0.498 (Non-Sig)

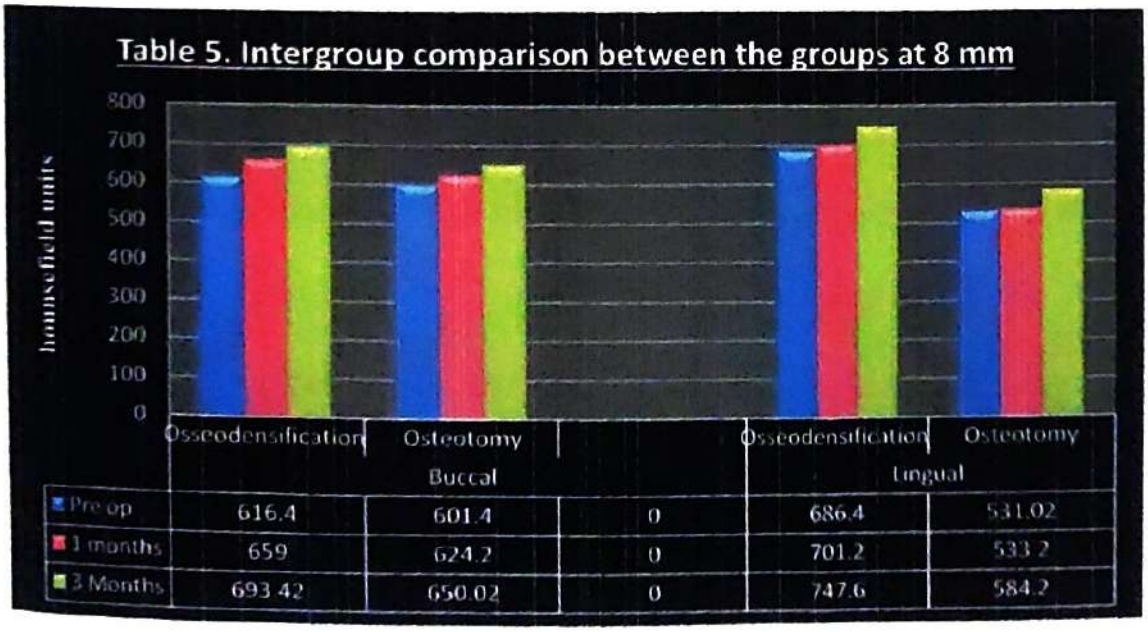


At the buccal side in the Osseo densification group the mean bone density at the pre treatment level was 526.60±110.30, at the 1 month time interval was 654.40±102.41and at the 3 month time interval was 727.20±89.14. The percentage change at the 1 months was -31.37±49.34 and at the 3 months was -46.22±51.40 In the osteotomy group the mean bone density at the pre treatment level was 576.80±183.72 at the 1 month time interval was 592.40±158.73 and at the 3 month time interval was 584.00±110.48. The percentage change at the 1 months was -.30±14.80 and at the 3 months was -.24±23.16. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05

At the lingual side in the Osseo densification group the mean bone density at the pretreatment level was 600.80±133.85, at the 1 month time interval was 598.40±148.44 and at the 3 month time interval was 584.00±110.48. The percentage change at the 1 months was -.30±14.80 and at the 3 months was -.24±23.16 In the osteotomy group the mean bone density at the pretreatment level was 546.40±222.22 at the 1 month time interval was 555.60±193.73 and at the 3 month time interval was 562.60±121.99. The percentage change at the 1 months was -4.81±13.74 and at the 3 months was -12.70±31.66. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

Table 5. Intergroup comparison between the groups at 8 mm

	Group	Pre op	1 months	3 Months	Change at 1 month	Change at 3 month	% Change at 1 month	% Change at 3 month
Buccal	Osseodensification	616.40±112.42	659.00±111.95	693.42±115.45	-42.60±76.22	-77.00±64.36	-7.63±13.44	-13.09±11.76
	Osteotomy	601.40±117.74	624.20±122.55	650.02±128.27	-22.80±45.54	-48.60±67.05	-3.91±7.66	-8.41±11.33
P value							0.610 (Non-Sig)	0.540 (Non-Sig)
Lingual	Osseodensification	686.40±181.52	701.20±163.53	747.60±144.42	-14.80±43.40	-61.20±86.08	-2.87±7.10	-10.95±15.88
	Osteotomy	531.02±109.94	533.20±95.71	584.20±134.09	-2.20±17.81	-53.20±92.22	-0.91±3.41	10.50±16.62
P value							0.593(Non-Sig)	0.967 (Non-Sig)

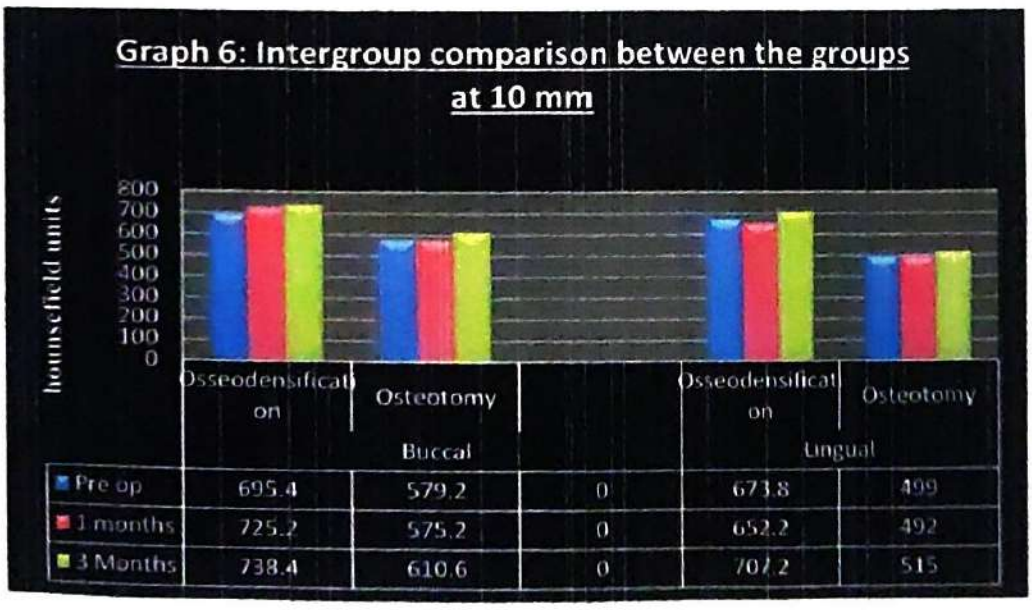


At the buccal side in the Osseo densification group the mean bone density at the pre treatment level was 616.40±112.42, at the 1 month time interval was 659.00±111.95 and at the 3 month time interval was 693.42±115.45. The percentage change at the 1 months was -7.63±13.44 and at the 3 months was -13.09±11.76 In the osteotomy group The mean bone density at the pre treatment level was 601.40±117.74 at the 1 month time interval was 624.20±122.55 and at the 3 month time interval was 650.02±128.27 The percentage change at the 1 months was -3.91±7.66 and at the 3 months was -8.41±11.33. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05

At the lingual side in the Osseo densification group the mean bone density at the pretreatment level was 686.40±181.52, at the 1 month time interval was 701.20±163.53 and at the 3 month time interval was 747.60± 144.42 . The percentage change at the 1 months was -2.87±7.10 and at the 3 months was-10.95±15.88 In the osteotomy group the mean bone density at the pre treatment level was 531.02±109.94 at the 1 month time interval was 533.20±95.71 and at the 3 month time interval was 584.20±134.09. The percentage change at the 1 months was --0.91±3.41and at the 3 months was 10.50±16.62. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

Table 6. Intergroup comparison between the groups at 10 mm

	Group	Pre op	1 months	3 Months	Change at 1 month	Change at 3 month	% Change at 1 month	% Change at 3 month
Buccal	Osseodensification	695.40±110.87	725.20±104.59	738.40±116.67	-29.80±11.21	-43.0±32.77	-4.48±2.01	-6.21±5.11
	Osteotomy	579.20±59.79	575.20±53.27	610.60±51.65	4.00±57.09	-31.4±46.34	.2307±9.73	-5.82±8.24
P value							0.319 (Non-Sig)	0.930 (Non-Sig)
Lingual	Osseodensification	673.80±164.24	652.20±170.42	707.20±17085	21.6±34.81	-33.40±56.94	3.48±5.85	-5.20±10.57
	Osteotomy	499.00±70.55	492.00±82.27	515.00±70.96	7.00±24.92	-16.00±19.68	1.58±5.16	-3.33±4.35
P value							0.601 (Non-Sig)	0.717 (Non-Sig)



At the buccal side in the Osseo densification group the mean bone density at the pre treatment level was 695.40±110.87 at the 1 month time interval was 725.20±104.59 and at the 3 month time interval was 738.40±116.67 . The percentage change at the 1 months was -4.48±2.01 and at the 3 months was -6.21±5.11 In the osteotomy group The mean bone density at the pre treatment level was 579.20±59.79 at the 1 month time interval was 575.20±53.27 and at the 3 month time interval was 610.60±51.65 The percentage change at the 1 months was .2307±9.73 and at the 3 months was -5.82±8.24 . The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05

At the lingual side in the Osseo densification group the mean bone density at the pre treatment level was 673.80±164.24 , at the 1 month time interval was 652.20±170.42 and at the 3 month time interval was 707.20±17085. The percentage change at the 1 months was 3.48±5.85 and at the 3 months was -5.20±10.57 In the osteotomy group the mean bone density at the pre treatment level was 499.00±70.55 at the 1 month time interval was 492.00±82.27 and at the 3 month time interval was 515.00±70.96. The percentage change at the 1 months was 1.58±5.16 and at the 3 months was -3.33±4.35. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

month time interval was 729.17±88.73 The percentage change at the 1 months was -7.62±17.50 and at the 3 months was -17.96±31.64 In the osteotomy group the mean bone density at the pre treatment level was 528.57±130.40 at the 1 month time interval was 526.12±109.68 and at the 3 month time interval was 561.83±100.95. The percentage change at the 1 months was -0.82±11.53 and at the 3 months was -8.75±16.76. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation. The level of the significance for the present study was fixed at 5%.

The intergroup comparison for the difference of mean scores between independent groups was done using the independent t test

The ***Shapiro–Wilk test*** was used to investigate the distribution of the data and ***Levene's test*** to explore the homogeneity of the variables. The data were found to be homogeneous and normally distributed. Mean and standard deviation (SD) were computed for each variable

Endosseous implants are now an important element of the practice of dentistry. The effectiveness of osseointegrated implants as a feasible substitute for partially and totally edentulous individuals has been proven by several studies. The success of an implant is determined on the rate of osseointegration.

Osseointegration of dental implants :

Per Ingvar Brånemark laid the scientific groundwork for contemporary Implantology. In 1950s investigations on the microcirculation of rabbit bone, Brånemark revealed that titanium chambers got permanently merged into bone. The live bone might become so bonded with the titanium oxide layer of the implant that the two could not be separated without fracture. [51] As a result, Brånemark coined the term "osseointegration" to describe this method of stable fixation between titanium and bone tissue. [52]

Initially, osseointegration was defined as a direct structural and functional connection between ordered living bone and the surface of a load carrying implant. When there is no progressive relative movement between the implant and the bone with which it is in direct contact, the implant is said to be osseointegrated. [53] Osteogenesis occurs at all stages of life as a result of both bone turnover and reparative processes. As a result, osseointegration can be thought of as the final step in a series of processes involved in bone healing around implants.

Bone-Implant Interface [19]

Osseointegration is a remarkable phenomenon in which bone directly opposes the implant surface without the use of any interposing collagen or fibroblastic matrix. Numerous studies have indicated that an Osseointegrated implant has significantly superior strength than a fibrous encapsulated implant. Furthermore, the strength of the contact between bone and implant grows rapidly following

implant implantation (0–12 weeks). This strength could be related to the amount of bone that surrounds the implant surfaces. Biophysical stimulation and the amount of time available for healing are two more factors that may influence the strength of the interaction. According to studies, measurable increases in bone implant interactions occur for at least three years.

Key Factors for Successful Implant Osseointegration:

The success of any implant procedure is dependent on the interdependence of the following factors:[54]

1. Biocompatibility of the implant material
2. The macroscopic and microscopic nature of the implant surface
3. The implant bed's health (non-infected) and morphologic (bone quality) status
4. The surgical technique
5. The period of uninterrupted healing
6. The subsequent prosthetic design and long-term loading phase

Stages of Osseointegration

Direct bone healing, as it occurs in defects, primary fracture healing and in Osseointegration is activated by any lesion of the pre-existing bone matrix. When the matrix is exposed to extra cellular fluid, noncollagenous proteins and growth factors are set free and activate bone repair [55]

Once activated; osseointegration follows a common, biologically determined program that is subdivided into 3 stages:[56]

1. Incorporation by woven bone formation;
2. Adaptation of bone mass to load (lamellar and parallel-fibered bone deposition);

3. Adaptation of bone structure to load (bone remodeling).

Bone quality and osseointegration:

Clinically, osseointegration refers to the mechanical anchoring of a dental implant into the jaw bone that lasts under all normal oral function circumstances. Consequently, bone regeneration associated with dental implants in a healthy state is a complicated process that might take a few weeks. Numerous biological phenomena (bone regeneration) are regulated a few days after implantation by several growth and differentiation factors secreted in the implant region. [66,67]

Bone regeneration occurs either on the implant surface (de novo bone creation, contact osteogenesis) or from the surrounding bone towards the implant surface (distance osteogenesis).[70] Finally, bone remodeling occurs at the implant site by replacing immature bone with mature bone, giving biological (mechanical) stability subsequent to primary fixation established during implant placement. [73]

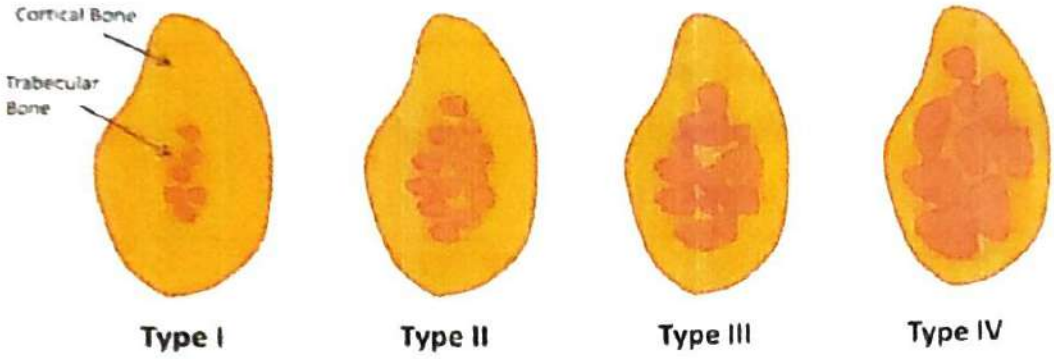
Hence, the quantity and quality of alveolar bone during implant placement has a large impact on the early and long-term success of dental implants. [68,69]

Poor bone quality and quantity have been identified as risk factors for implant biological issues, which are accompanied with a lack of primary stability and poor healing / osseointegration, which could also result in early implant loss. [69]

During treatment planning for dental implants, the exterior architecture and volume of the dentate or edentulous alveolar bone are mainly examined to predict the prognosis of the treatment. The exterior and internal architecture of bone influences almost every aspect of implant dentistry practice, including implant design selection, surgical technique, healing period, type of future prosthetic reconstruction, and so on.

Lekholm & Zarb classification:

The bone categorization system is explained by Lekholm U, Zarb GA as follows: Bone quality has been divided into four groups based on its radiographic appearance and resistance to drilling. [71]



Type I - the entire bone is composed of very thick cortical bone

Type II - thick layer of cortical bone surrounds a core of dense trabecular bone

TypeIII - thin layer of cortical bone surrounds a core of trabecular bone of good strength

Type IV- very thin layer of cortical bone with low density trabecular bone of poor strength

Reference	Tool used in classification	Type of bone	Images
Lekholm & Zarb (1985)	Plain radiography. Morphology	Type 1: Homogeneous cortical bone	
		Type 2: Thick cortical bone with marrow cavity	
		Type 3: Thin cortical bone with dense trabecular bone of good strength	
		Type 4: Very thin cortical bone with low density trabecular bone of poor strength	

Table 7. lekholm and zarb classification

Misch's classification of bone density : [72]

Misch classified bone density types into following classes based on the trabecular and cortical parts of these bone macroscopically.

Table 8. Misch's classification of bone density

Bone classes	Description	Bone density (hounsefield units)	Localisation
D1	Dense cortical bone	>1250	Anterior mandible
D2	Porous cortical bone and dense trabecular bone	850-1250	Anterior and posterior mandible; anterior maxilla
D3	Thin and porous cortical bone and thin trabecular bone	350-850	Anterior and posterior maxilla; mandible
D4	Thin trabecular bone	150-350	Posterior mandible
D5	Non mineralized bone (unsuitable for implant)	<150	-

University of California Los Angeles (UCLA) classification: [74]

The University of California Los Angeles (UCLA) created a three-dimensional categorization of edentulous alveolar bone based on bone volume and form. During implant placement at the optimal restorative driving position, the doctor observed the bone volume in the horizontal and vertical dimensions. There were up to eight classifications based on the degree of insufficient ridge volume in apical, horizontal patterns. This classification was modified and regrouped into four types :

Type I - sufficient bone in horizontal and vertical dimensions, making it ideal for implant placement.

Type II – insufficient bone volume on the buccal side.

Type III – knife-shaped like alveolar bone or major deficiency bone volume on the buccal side, but with sufficient heights.

Type IV - insufficient alveolar heights and width with all sides of implant, are exposed.

Type IV - complete opposite of Type I in this category.

Table 9. representing edentulous bone ridge classification followed three-dimensional (3D) quantity of alveolar bone shape and volume.

Classification System	Tool used in classification	Type of bone	Images
Modified UCLA classification, 2008	Clinical Observation (Bone shape and volume)	Type 1: Sufficient alveolar shape for implants	
		Type 2: Insufficient alveolar bone volume on the buccal side	
		Type 3: Knife edge shape with sufficient alveolar bone height	
		Type 4: Insufficient alveolar bone height	

Four facts serve as the foundation for modifying treatment plans based on bone quality.

1) Each bone density has a different strength

2) Bone density affects the elastic modulus

3) Bone density differences result in different amounts of bone-implant contact percent

4) Bone density differences result with a different stress-strain distribution at the implant-bone interface.

The strength of the bone reduces as bone density decreases. The load on the bone should be minimized to lessen the occurrence of microfracture.

Stress and strain are inextricably linked. When a result, as bone density diminishes, so should the load on the implant system. Prosthesis design to minimize force is one technique to lessen biomechanical demands on implants. [75]

Drawbacks of conventional osteotomy technique

Traditionally, the installation of dental implants loses a significant amount of bone tissue during the drilling technique, which is accomplished using a succession of surgical drills to establish an implant bed that precisely fits the implant.

Low-density bone implant locations have been recognized as one of the most significant possible risk factors impacting implant treatment result using conventional osteotomy procedure.

Standard drill designs used in dental implantology are made to excavate bone to create room for implant placement. They cut away bone effectively but typically do not produce a precise circumferential osteotomy. Osteotomies may become elongated and elliptical due to the chatter of the drills. In these circumstances, the implant insertion torque is reduced leading to poor primary stability and potential lack of integration. [76]

Furthermore, osteotomies drilled into narrow bone locations may produce dehiscence, buccally or lingually, which also reduces primary stability and will require an additional bone grafting procedure adding cost and healing time to treatment.

When standard drills extract enough bone to let strains in the remaining bone to reach or exceed the bone micro-damage threshold, the bone-remodeling unit (BMU) needs more than 3 months to repair the damaged area, so maintaining bone bulk will enhance healing and shorten the healing period. [77]

A clinical trial with instantly loaded implants revealed a greater failure rate in low density bones, confirming the hypothesis that primary stability is an important factor of the success of immediately loaded implants. [81-84]

Other techniques to overcome these drawbacks:

To address these disadvantages, several implantation procedures have been devised to produce a high degree of implant stability without removing further bone, especially in situations when bone density is limited (i.e., challenged condition). A surgical approach, for example, has been devised that compresses bone tissue laterally and apically using an *osteotome spreader*.[78] Furthermore, the 'undersized drilling' approach has been widely researched, and most implant manufacturers now suggest the *undersized drilling technique* for implant implantation.[79]

Local bone density is improved in this operation by lateral bone compression along the implant sides with a final drill diameter significantly smaller than the implant diameter. This approach produced greater insertion torque values, which indicate enhanced primary implant (mechanical) stability.[79] Aside from improving an implant's main stability, the undersized surgical technique demonstrated the additional benefit of osteogenic bone fragments becoming translocated and interspersed along the surface of the implant, with clear signs of these bone particles contributing to peri-implant bone healing and remodeling.[80]

The amount of bone to implant contact at the coronal aspect was statistically substantially lower in implants put using the under-preparation approach. This is due to the already under stressed bone being subjected to additional strain from immediate loading at the peri-implant bone tissue, which can interfere with the reparatory processes of bone remodeling during the early peri-implant wound healing phase, particularly at the coronal aspect of the implants. [85]

Several other procedures for enhancing local bone volume have been proposed in the literature, including lateral sinus lifting, GBR, and onlay block graft. The disadvantages of these treatments include a longer treatment duration, greater morbidity, and an extra surgical site at an additional expense to the patient.

Osseodensification :

One of the recent technique that has been introduced to improve primary stability and peripheral bone density is osseodensification technique. Huwais's osseodensification approach, announced in 2015, allows us to improve the bone tissue density surrounding the prepared implant site during surgery with sufficient drills intended to operate in opposing directions, with low-speed irrigation (by preventing overheating of the tissue, and hence necrosis).

A comparison of the quantity and quality of autologous bone retained by the preparation with osseodensification vs. the Summer's osteotomes revealed a BIC more than 19.4% with the use of the Versah drill technique (Densah, MI, USA). The Osseodensification technique uses special burs in noncutting rotation, demonstrated the ability to significantly increase (approximately 30% higher) the %BV around the implants and to improve secondary implant stability (expressed as removal torque values and micromotion under lateral forces). The histological investigation revealed that the healing process is not hampered by this bone condensation and that bone density growth is seen around the implant surface (particularly in the top region of the implant).[37]

Densah burs design and its action:

This bone preservation approach is made feasible by a specifically constructed bur with several lands with a significant negative rake angle that act as non-cutting edges to promote bone density as they widen an osteotomy. Regular twist drills or straight fluted drills have 2-4 lands to guide them through the osteotomy. Densah® Burs are built with four or more lands that perfectly guide them through bone. More land means less potential noise. Densah® Burs create regulated bone plastic deformation during osseodensification, allowing the extension of a cylindrical osteotomy without digging any bone tissue.

I. Modes

The drilling is done at fast speeds using both Cutting Mode (Clockwise rotation) at 800-1500 RPMs Densifying Mode (Counterclockwise) rotation (800-1500 rpm). The counter clockwise drilling orientation is used in low density bone, while the clockwise drilling direction is preferred in greater density bone.

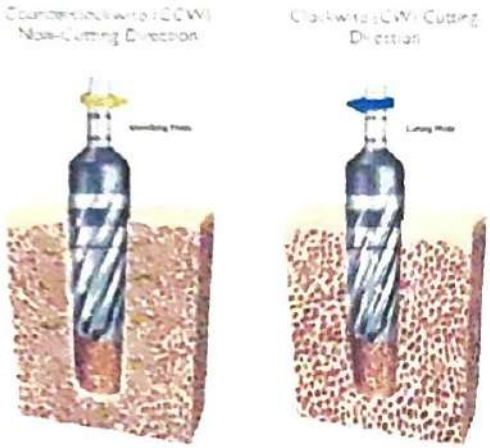


Fig. 20. modes of densah burs.

II. Motion

Densah® Burs should always be used in a **Bouncing-Pumping motion** with profuse irrigation (small vertical pressure to push the drill into the osteotomy, then draw out for pressure release, then advance with vertical pressure again, and so on in an in/out pattern). Bone density and desired length generally govern the time and number of bouncing-pumping events (in/out).

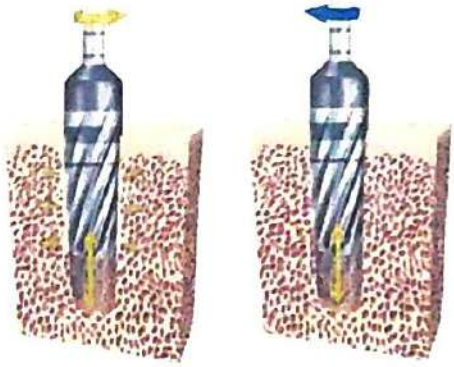


Fig. 21 pumping motion of densah burs

III. Densify After Cut Protocol

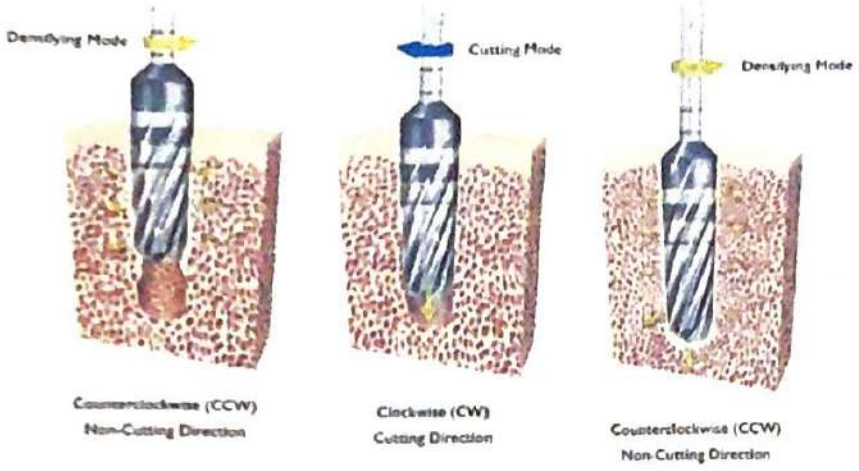


Fig.22. Densify after cut protocol

Densah® Burs can be used in both cutting and densifying modes simultaneously. Using the same Densah® Bur, it may be moved between various osteotomy sites in a patient, cutting in one and densifying in another. The same Densah® Bur can be used to densify — cut — densify again inside the same osteotomy in hard bone.

IV. Densah® Bur Marking

Densah® Burs are externally irrigated and intended for drill speeds ranging from 800-1500 rpm. They have laser marks ranging in depth from 8 to 20 mm. Densah® Burs feature a tapered design, and their catalog number reflects their minor and major diameter dimensions. Densah® Bur VT3848, for example, has a tip diameter of 3.8 mm, a coronal diameter of 4.8 mm, and an average diameter of (4.3 mm).

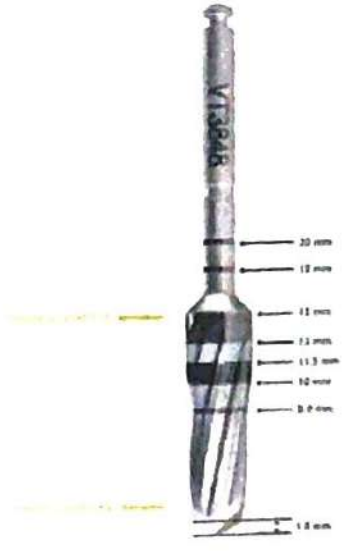


Fig.23. Markings on densah bur

Since the bur-to-bone contact produces an opposing axial reaction force proportional to the strength of the surgeon's force, the surgeon may safely manage the osseous densification process. This provides haptic input to the surgeon, allowing him to modulate force depending on the bone density encountered and to aid the strain-rate controlled plastic deformation that compacts the bone and extends the osteotomy.

Osseodensification, unlike standard bone drilling procedures, does not entail the removal of bone tissue. To create the osteotomy, it compacts and autografts bone tissue in an outwardly expanding orientation. It is accomplished by the application of trademarked densifying burs.

A thick compacted layer of bone tissue is generated around the walls and base of the osteotomy when the densifying bur is operated at high speed in a reversed, non-cutting orientation with steady external irrigation (Densifying Mode) (Meyer. Huwais, et al., 2014).

Osseodensification (OD) has also improved implant stability by increasing peripheral and apical bone mineral density, bone-to-implant contact (BIC), and percentage of bone volume (BV) around it [46,49, 64,65]. Hindi et al. proposed the use of the OD method to improve bone density in low-bone density zones and show a statistically significant change in mean bone density assessed at the apical site of the implant. [61]

Methods to assess bone quality and quantity:

There are two types of assessment methods for bone quality and quantity.

1. Direct measurement techniques:

Ex vivo studies (i.e., dry skulls or cadavers) or sample / biopsy retrieved for analysis from animals or human subjects, as well as in vivo studies on live subjects, are examples of direct measurement techniques.

2. Indirect measurement techniques.

Radiographic imaging, such as CT or CBCT. These techniques provide a three-dimensional representation of bony structures and are regarded as an accurate diagnostic tool that, in addition to linear measurements, allows for evaluation of the morphology, bone quality, and volume of the residual alveolar ridge. [86]

Why CBCT

The most often used diagnostic method for measuring bone density is cone beam computed tomography (CBCT). [59] Even though Hounsfield units (HU) are not directly applicable to CBCT, there has been some controversy. [60] CBCT has been the gold standard for many years due to the nature of information it provides, which is 3-dimension and most accurate. The accuracy of CBCT for identifying trabecular bone density was compared to microcomputed tomography and multislice computed tomography (MSCT). Their findings revealed a high association between CBCT and MSCT, implying that CBCT can be utilized to determine bone mineral density at the implant site. [61] Al-Jamal and Al-Jumaily, [62] found that utilizing CBCT to determine bone density is an effective method that is linked to primary stability. Chennoju et al., [63] conclude that the CBCT was effective in calculating the original density using grey standards of CBCT scans.

Along with, lower radiation dose, reduced costs and the relative grey density values of CBCT images make it a useful substitute for computerized tomography (CT). [87,88]

The present study evaluated the bone density at peri implant site using osteotomy and osseodensification technique, which was measured using CBCT reports. The study included two groups, control group included the conventional osteotomy group and the test group included the osseodensification group. The study comprised patients which were healthy and partially or completely edentulous patients; they were selected from the outdoor patient of clinical Department of Prosthodontics & Crown and Bridge at Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh.

Control group : 20 implants placed with conventional osteotomy.

Test Group: 20 implants placed with osseodensifcation technique.

To assess the effect of type of technique used to place the implants on bone density, a base line measurement of bone mineral density was recorded from the buccal and lingual wall, to use as a comparative parameter for both the groups. Bone mineral density was evaluated at intervals of 2mm, starting from the crest (0mm) then at 2mm and so on till 10mm in Hounsfield units(HU).

The comparison of the bone mineral density at the buccal and lingual wall of the implant placement site is summarized for the test and control group over the proposed intervals in Table 1 to 6 and also depicted in the graphs following the table.

The overall comparison of the average values of the bone mineral density at the peri implant site of the test group and the control at proposed intervals is summarized in table 7 and graph 7.

When compared with the pre-operative CBCT values, at 0mm, on the buccal side of the osseodensification group the percentage change at 1 month was -13.15±38.59 and at 3 months was -22.04±44.03. The percentage change for osteotomy group at 1 month was 2.80±14.37 and at 3 months was -4.50±15.71.

The intergroup comparison between Osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

When compared with the pre-operative CBCT values at 0mm, on the lingual side in the Osseodensification group the percentage change at 1 month was 0.03±5.77 and at 3 months was -47.43±103.12. The percentage change at 1 month was 1.07±4.40 and at 3 months was -15.14±23.62. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

When compared with the pre operative CBCT values at 2mm, on the buccal side in the osseodensification group the percentage change at 1 month was -14.67±30.74 and at 3 months was -19.60±26.78. In osteotomy site the

percentage change at 1 month was -2.96±18.33 and at 3 months was -10.08±23.06. The intergroup comparison between Osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

At the lingual side in the Osseo densification group the percentage change at 1 month was -7.18±10.24 and at 3 months was -19.55±29.43. In the osteotomy group the percentage change at 1 month was 0.87±23.08 and at 3 months was 0.34±22.56. The intergroup comparison between Osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

When compared with the pre operative CBCT values at 4mm, on the buccal side in the Osseo densification group the percentage change at 1 month was -22.94±54.10 and at 3 months was -23.27±44.16. In the osteotomy group the percentage change at 1 months was -6.75±26.20 and at 3 months was -23.19±32.61. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

At 4mm, on the lingual side in the Osseo densification group the percentage change at 1 month was 1.90±8.62 and at 3 months was -25.39±34.73. In the osteotomy group the percentage change at 1 month was 3.86±7.03 and at 3 months was -8.54±19.02. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

When compared with the pre operative CBCT values at 6mm, on the buccal side in the osseodensification group the percentage change at 1 month was -31.37±49.34 and at 3 months was -46.22±51.40. In the osteotomy group the percentage change at 1 month was -.30±14.80 and at 3 months was -.24±23.16. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

At the lingual side in the Osseo densification group the percentage change at 1 month was -.30±14.80 and at 3 months was -.24±23.16. In the osteotomy group the percentage change at 1 month was -4.81±13.74 and at 3 months was -

12.70±31.66. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

When compared with the pre operative CBCT values at 8mm, on the buccal side in the osseodensification group the percentage change at 1 months was -7.63±13.44 and at 3 months was -13.09±11.76. In the osteotomy group the percentage change at 1 months was -3.91±7.66 and at 3 months was -8.41±11.33. The intergroup comparison between Osseo densification group and osteotomy group was statistically non-significant with p value of more than 0.05.

At the lingual side in the osseodensification group the percentage change at 1 months was -2.87±7.10 and at 3 months was-10.95±15.88. In the osteotomy group the percentage change at 1 month was -0.91±3.41and at 3 months was 10.50±16.62. The intergroup comparison between osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

When compared with the pre-operative CBCT values at 10mm, on the buccal side in the osseodensification group the percentage change at 1 month was -4.48±2.01 and at 3 months was -6.21±5.11. In the osteotomy group the percentage change at 1 month was .2307±9.73 and at 3 months was -5.82±8.24. The intergroup comparison between osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05

At the lingual side in the osseodensification group the percentage change at 1 month was 3.48±5.85 and at 3 months was -5.20±10.57. In the osteotomy group the percentage change at 1 month was 1.58±5.16 and at 3 months was -3.33±4.35. The intergroup comparison between Osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

The overall average percentage change in the Osseodensification group the at the period of 1 months was -7.62±17.50 and at 3 months was -17.96±31.64. In the osteotomy group the percentage change at 1 month was -0.82±11.53 and at 3 months was -8.75±16.76. The intergroup comparison

between osseodensification group and osteotomy group was statistically non-significant with p value of more than 0.05.

As per the observation seen in the present study, the difference change of mean values at 1 month and 3 months for osseodensification (OD) and Osteotomy(OS) were { 31.83 (OD), 83.85 (OD); 2.45 (OS), 33.26(OS) } respectively. The above results show that there is significantly greater increase in the bone density when an implant is placed with osseodensification procedure rather than when placed with osteotomy procedure. When compared to traditional drilling, the results firmly demonstrated that the OD drilling approach had no deleterious impact on bone repair. As a consequence, while choosing between normal drilling and osseodensification with compromised bone conditions (Misch's D3 and D4 bone), osseodensification over osteotomy provides a better prognosis.

Further research including a large number of patients and addressing long term monitoring of peri-implant alveolar bone mineral density is required to strengthen the conclusion about the utility and predictability of the osseodensification procedure.

LIMITATIONS OF THE STUDY

- The study's weaknesses are mostly related to its observational approach and short period of investigation.
- The location (arch, quadrant) of the implant was not specified.
- Implants of both the groups were placed in different patients and each patient has different healing rate.

The following conclusion has been reached based on observations, statistical analysis, and evidence-based discussion:

- The osseodensification technique enhanced bone mineral density within the constraints of this investigation.

- When compared to traditional drilling, drilling method had no negative influence on bone recovery.

- When compared with pre-operative values and post-operative values at one month and three month interval there was improved bone mineral density at peri implant site in osseodensification technique.

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ANNEXURE 1

Babu Banarasi Das University
Babu Banarasi Das College of Dental Sciences,
BBD City, Faizabad Road, Lucknow – 226028 (INDIA)

Dr. Lakshmi Bala
Professor and Head Biochemistry and
Member-Secretary, Institutional Ethics Committee

Communication of the Decision of the IX[th] Institutional Ethics Sub-Committee

IEC Code: 23 **BBDCODS/04/2022**

Title of the Project: Assessment of bone density at peri implant site using osteotomy and osseodensification technique.

Principal Investigator: Dr Krishna Priyadarshani **Department:** Prosthodontics and Crown & Bridge

Name and Address of the Institution: BBD College of Dental Sciences Lucknow.

Type of Submission: New, MDS Project Protocol

Dear Dr Krishna Priyadarshani,

The Institutional Ethics Sub-Committee meeting comprising following four members was held on 07[th] April, 2022.

1.	Dr. Lakshmi Bala Member Secretary	Prof. and Head, Department of Biochemistry, BBDCODS, Lucknow
2.	Dr. Amrit Tandan Member	Prof. & Head, Department of Prosthodontics and Crown & Bridge, BBDCODS, Lucknow
3.	Dr. Rana Pratap Maurya Member	Reader, Department of Orthodontics, BBDCODS, Lucknow
4.	Dr. Akanksha Bhatt Member	Reader, Department of Conservative Dentistry & Endodontics, BBDCODS, Lucknow

The committee reviewed and discussed your submitted documents of the current MDS Project Protocol in the meeting.
The comments were communicated to PI thereafter it was revised.

Decisions: The committee approved the above protocol from ethics point of view.

Forwarded by:

Lakshmi Bala

(Dr. Lakshmi Bala)
Member-Secretary
IEC
Member-Secretary
Institutional Ethic Committee
BBD College of Dental Sciences
BBD University
Faizabad Road, Lucknow-226028

(Dr. Puneet Ahuja)
Principal
PRINCIPAL
BBDCODS
Babu Banarasi Das College of Dental Sciences
(Babu Banarasi Das University)
BBD City, Faizabad Road, Lucknow-226028

ANNEXURE 2

BABU BANARASI DAS COLLEGE OF DENTAL SCIENCES (FACULTY OF BBD UNIVERSITY), LUCKNOW

INSTITUTIONAL RESEARCH COMMITTEE APPROVAL

The project titled **"Assessment of Bone Density at Peri Implant Site using Osteotomy and Osseodensification Technique"** submitted by Dr **Krishna Priyadarshani** Post graduate student from the **Department of Prosthodontics and Crown & Bridge** as part of MDS Curriculum for the **academic** year 2020-2023 with the accompanying proforma was reviewed by the Institutional Research Committee present on **11th October 2021** at BBDCODS

The Committee has granted approval on the scientific content of the project. The proposal may now be reviewed by the Institutional Ethics Committee for granting ethical approval.

Prof. Vandana A Pant
Co-Chairperson

Prof. B. Rajkumar
Chairperson

ANNEXURE 3

Babu Banarasi Das College of Dental Sciences

(Babu Banarasi Das University)

BBD City, Faizabad Road, Lucknow – 227105 (INDIA)

Guidelines for Devising a Participant / Legally Acceptable Representative Information

Document (PID) in English

1. Study Title

Assessment of bone density at per implant site using osteotomy and osseodensification technique.

2. Invitation Paragraph

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with friends, relatives and your treating physician/family doctor if you wish. Ask us if there is anything that is not clear or if you would like more information.

3. What is the purpose of the study?

The aim of the study is to evaluate the changes in bone density in peri-implants site with osteotomy and osseodensification technique.

4. Why have I been chosen?

You are chosen as you fulfill the criteria for the study.

5. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

6. What will happen to me if I take part?

You will have to come at least 5-6 times, in the first visit the medical and dental history will be recorded. If required then you expected to come for a follow up appointment. As a volunteer, your responsibility will be to arrive on time.

7. What do I have to do?

There will be certain changes made in the dietary intake with few other precautionary measures, and you are expected to follow that.

Page 2 of 5

8. What is the procedure that is being tested?

Dental implants are screw like devices that are going to be surgically placed in your jaw bone, where they serve as an anchor for an artificial tooth called a crown. The bone density in peri-implant site will be assessed once before placing the implants by CBCT to know the available bone condition, and then two other CBCT will be taken after one month and three months to evaluate the density after placing the implants. When the surrounding soft and hard tissues heal completely then the crown is placed. You are expected to follow all the instructions given by your doctor bring the required medical reports and X-rays and CBCT reports every time you come to you doctor.

9. What are the interventions for the study?

Pre anaesthetic interventions include preoperative CBCT to determine the appropriate width and length of the proposed implant and to ensure the average bone density is suitable for implant placement. All the surgical procedure will be performed under local anesthesia (2% lidocaine). Prosthesis will be constructed and delivered after 3-6 months depending upon the healing and osseointegration.

10. What are the side effects of taking part?

There are as such no major side effects of the procedure itself. But there can be post-operative complications as pain and swelling at the site and in extreme cases loosening of the implants. If any of the situations occurs you should report immediately. In case of any emergency immediately call the doctor.

11. What are the possible disadvantages and risks of taking part?

There can be possible disadvantages of the procedure if you are having the following conditions and you might be susceptible to further risks so you might not be suitable for the procedure.

1. Patients with cardiovascular diseases (CVS) can endanger and reduce the amount of oxygen and nutrients in the osseous tissue which may affect the osseointegration process of dental implants. Patients with CVS have higher risk of getting infective endocarditis.

2. Patients going through radiotherapy.

3. Patients with Diabetes Mellitus are contraindicated

4. Diabetic people are more prone to infections and have higher rate of implants failure.

5. Osteoporosis, metabolic disease which modifies the bone mass and density, complicates the initial stability of dental implants because of loss in the bone mass.

6. Patients with habit of smoking.

7. Pregnant women are at risk so not allowed to take part in the study.

12. What are the possible benefits of taking part?

By taking part in this study you will be receiving a better treatment option at a lesser discomfort. These methods of placing implants yields better implant anchorage and longer implant life.

13. What if new information becomes available?

Sometimes during the course of a research project, new information becomes available about the research being studied. If this happens, you will be informed about it and the changes that can happen to the study then you will be free to decide if you want to continue it or not. If you decide to continue in the study, you may be asked to sign an updated consent form.

Page 3 of 5

14. What happens when the research study stops?

If the study finishes/stops before the stipulated time, then the reason for the same will be explained to you.

15. What if something goes wrong?

Volunteers will be taken care of by the doctors expertising in the field at BBDCODS opd.

16. Will my taking part in this study be kept confidential?

Your name, address or any personal or other information will not be shared outside the BBDCODS.

17. What will happen to the results of the research study?

Identity of the participants will not be disclosed in any result/ reports/ publications.

18. Who is organizing the research?

Study is organized by the researcher. Complete cost of the implant will be given by the patient.

19. Will the results of the study be made available after study is over?

If the patient wishes, the result of the study will be made available to him/ her.

ANNEXURE 4

CONSENT FORM

Title of the Study: "Assessment of bone density at peri implant site using osteotomy and osseodensification technique"

Study Number....

Subject's Full Name.....

Date of Birth/Age .

Address of the Subject...

Phone no. and e-mail address..

Qualification.

Occupation: Student/ Self Employed/ Service/Housewife/

Other (Please tick as appropriate)

Annual income of the Subject....

Name and of the nominees(s) and his relation to the subject.. ... (For the purpose of compensation in case of trial related death).

1. I confirm that I have read and understood the Participant Information Document dated.....for the above study and have had the opportunity to ask questions. OR I have been explained the nature of the study by the Investigator and had the opportunity to ask questions.

2.I understand that my participation in the study is voluntary and given with free will without any duress and that I am free to withdraw at any time, without giving any reason and without my medical care or legal rights being affected.

3. I understand that the sponsor of the project, others working on the Sponsor's behalf, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even ifI withdraw from the trial. However, I understand that my Identity will not be revealed in any information released to third parties or published.

I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).

5. I permit the use of stored sample (tooth/tissue/blood) for future research.

Yes [ ] No [ ] Not Applicable [ ]

6. I agree to participate in the above study. I have been explained about the complications and side effects, if any, and have fully understood them. I have also read and understood the participant/volunteer's Information document given to me.

Signature (or Thumb impression) of the Subject/Legally Acceptable Representative..

Signatory's Name... Date.

Signature of the Investigator... Date..

Study Investigator's Name... Date...

Signature of the witness. ... Date....

Name of the witness.

Received a signed copy of the PID and duly filled consent form

Signature/thumb impression of the subject or legally Date...

Acceptable representative

ANNEXURE 5

a) Osseodensification cases:

Implant site	Pre op		1 month		3month	
#11	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	422	228	761	236	840	756
2mm	391	384	663	479	652	658
4mm	373	462	818	400	754	856
6mm	377	671	820	773	856	457
8mm	563	545	738	553	754	756
10mm	564	474	604	423	564	457
#17	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	898	658	925	671	943	693
2mm	785	754	796	767	851	789
4mm	967	452	872	461	987	562
6mm	456	685	586	518	768	594
8mm	754	732	759	710	796	746
10mm	854	812	868	756	876	834
# 47	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	752	478	756	489	785	502
2mm	847	785	875	795	887	832
4mm	754	745	768	794	815	812
6mm	658	456	687	468	721	543
8mm	458	985	475	972	498	981
10mm	752	854	793	865	805	897
#36	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	895	854	725	766	788	773
2mm	625	475	612	512	721	547
4mm	754	957	763	875	772	941
6mm	564	735	576	746	637	759
8mm	675	586	658	674	724	632
10mm	658	683	687	652	713	676
#16	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	669	465	675	476	761	487
2mm	678	768	686	771	697	773
4mm	779	668	796	694	792	735
6mm	578	457	603	487	654	567
8mm	632	584	665	597	695	623
10mm	649	546	674	565	734	672

Values measured from crest of ridge at intervals of 2mm, in hounsefield units (HU)

b) Osteotomy cases

Implant site	Pre op		1 month		3month	
1. #11	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	469	228	561	236	614	356
2mm	458	384	620	479	692	458
4mm	373	462	561	400	673	656
6mm	390	671	642	773	658	687
8mm	589	545	692	553	754	756
10mm	531	474	604	423	624	457
2 #17	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	885	654	724	643	784	647
2mm	752	875	678	537	723	532
4mm	456	457	498	418	531	443
6mm	784	785	685	659	703	567
8mm	699	631	689	605	694	654
10mm	648	565	563	574	612	587
3 #45	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	667	453	587	434	674	469
2mm	679	464	645	475	684	494
4mm	688	562	691	574	697	543
6mm	765	658	776	645	764	675
8mm	743	643	754	640	775	612
10mm	641	583	652	589	689	598
4 # 31	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	457	365	452	342	463	375
2mm	432	423	421	437	429	435
4mm	438	434	387	423	456	445
6mm	476	312	391	345	491	408
8mm	489	412	491	432	504	434
10mm	542	431	521	429	564	465
5 #32	Buccal	Lingual	Buccal	Lingual	Buccal	Lingual
0mm	465	334	454	345	468	382
2mm	445	416	431	432	459	453
4mm	438	432	374	445	498	452
6mm	469	306	468	356	497	476
8mm	487	424	495	436	523	465
10mm	534	442	536	445	564	468

Values measured from crest of ridge at intervals of 2mm, in hounsefield units (HU)

ANNEXURE 6

STATISTICAL ANALYSIS

The data for the present study was entered in the Microsoft Excel 2007 and analyzed using the SPSS statistical software 23.0 Version. The descriptive statistics included mean, standard deviation. The level of the significance for the present study was fixed at 5%.

The intergroup comparison for the difference of mean scores between independent groups was done using the independent t test

The ***Shapiro–Wilk test*** was used to investigate the distribution of the data and ***Levene's test*** to explore the homogeneity of the variables. The data were found to be homogeneous and normally distributed. Mean and standard deviation (SD) were computed for each variable

Mean

$$\overline{X} = \frac{\Sigma X}{N}$$

Where:

$\overline{X}$ = the data set mean

$\sum$ = the sum of

X = the scores in the distribution

N = the number of scores in the distribution

Range

$$range = X_{highest} - X_{lowest}$$

Where:

$X_{highest}$ = largest score

X_{lowest} = smallest score

Variance

$$SD^2 = \frac{\Sigma(X - \overline{X})^2}{N}$$

The simplified variance formula

$$SD^2 = \frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}$$

Where:

SD^2 = the variance

Σ = the sum of

X = the obtained score

$\overline{X}$ = the mean score of the data

N = the number of scores

Standard Deviation (N)

$$SD = \sqrt{\frac{\Sigma(X - \overline{X})^2}{N}}$$

The simplified standard deviation formula

$$SD = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}}$$

Where:

SD = the standard deviation

Σ = the sum of

X = the obtained score

$\overline{X}$ = the mean score of the data

N = the number of scores

Independent t-test

Independent t Test can be used to determine if two sets of data are significantly different from each other, and is most commonly applied when the test statistic would follow a normal distribution. The independent samples *t*-test is used when two separate sets of independent and identically distributed samples are obtained, one from each of the two populations being compared

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\left(\frac{(N_1 - 1)s_1^2 + (N_2 - 1)s_2^2}{N_1 + N_2 - 2}\right)\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}}$$

Where X1 =Mean of the first Group, X2 =Mean of the Second Group

ANNEXURE 7

PLAGIARISM REPORT

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