REHABILITATION OF NARROW RIDGE WITH RIDGE SPLIT USING PIEZOTOME V/S ROTARY ALONG WITH BONE GRAFT - A CLINICAL COMPARATIVE STUDY

Dissertation submitted to

THE TAMILNADU Dr. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the degree of

MASTER OF DENTAL SURGERY

BRANCH II

PERIODONTOLOGY

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CHENNAI – 600032

2016 – 2019

CERTIFICATE – I

This is to certify that **Dr. G.ABIRAMI (Reg No:241613551)** Post Graduate student (2016-2019) in the Department of Periodontology, CSI College of Dental Sciences and Research, has done this dissertation titled **"REHABILITATION OF NARROW RIDGE WITH RIDGE SPLIT USING PIEZOTOME V/S ROTARY ALONG WITH BONE GRAFT-A CLINICAL COMPARATIVE STUDY"** under our guidance and supervision in partial fulfillment of the regulations laid down by **The Tamilnadu Dr. M.G.R. Medical University**, Chennai – 600032 for **M.D.S.,** (Branch –II) **Periodontology** degree examination.

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PLACE OF STUDY	**CSI College of Dental Sciences and Research , Madurai**
DURATION OF COURSE	**3 years**
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This is to certify the dissertation titled **"REHABILITATION OF NARROW RIDGE WITH RIDGE SPLIT USING PIEZOTOME V/S ROTARY ALONG WITH BONE GRAFT - A CLINICAL COMPARATIVE STUDY"** of the candidate **DR. G.ABIRAMI (Reg No:241613551)** for the award of **MASTER OF DENTAL SURGERY** in the **BRANCH II - PERIODONTOLOGY.**

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DR. G.ABIRAMI

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Abbreviations

LIST OF ABBREVIATIONS

S.NO	ABBREVIATIONS	DESCRIPTIONS
1	**RPM**	Revolutions Per Minute
2	**kHz**	Kilohertz
3	**RFA**	Resonance Frequency Analysis
4	**ISQ**	Implant Stability Quotient
5	**Ncm**	Newton Centimetre
6	**mm**	Millimetre
7	**CBCT**	Cone Beam Computed Tomography
8	**OPG**	Orthopantamogram
9	**Er:YAG**	erbium-doped yttrium aluminium garnet
10	**BMP**	Bone Morphogenetic Proteins
11	**TGF**	Transforming Growth Factor

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Abstract

AIM

To compare the implant stability, bucco-lingual width of the alveolar ridge and marginal bone loss around implants, after ridge split technique and implant placement using piezoelectric bone surgery and rotary instruments.

MATERIALS AND METHODS

A split mouth study design was done among 5 patients with bilateral partially edentulous sites with horizontal ridge deficiency in posterior mandibular arch. In control sites, ridge split procedure and implant site preparation done using traditional rotary instruments and in the experimental sites, ridge split procedure and implant site preparation done using piezoelectric device. Clinical parameters such as Implant stability, Bucco-lingual ridge width and Marginal bone loss around implants were recorded.

RESULTS

There was an increase in implant stability in both piezo and rotary treated sites, but comparatively more in test site when compared to control site. There was also statistically significant increase in bucco-lingual width of the ridge in test sites in 3 months. There was no significant change in marginal bone level on both sites.

CONCLUSION

The implant stability and bucco-lingual ridge width were comparatively more in test site than in control site which shows the efficiency of piezoelectric device. Overall, the test sites showed desirable results when compared to control sites.

KEYWORDS: Dental implants, Ridge split, Piezosurgery, Rotary instruments.

Introduction

Dental implants are the most recent and acceptable treatment procedure for rehabilitation of missing teeth. Dental implant is an artificial tooth root replacement and is used to support restoration that resembles a natural tooth or group of natural teeth[56].In ancient days materials like carved bamboo pegs, copper pegs and seashells were used to replace the missing teeth. In 18th century researchers were began to experiment with alloys and gold. In 1952, during a research the Swedish orthopedic surgeon P.I**.**Brånemark observed that bone grow around titanium in rabbit, he decided to use this concept in rehabilitation of missing teeth and placed his first titanium dental implant in a human volunteer in 1965. In 1977 he coined the term osseointegration to explain the direct structural and functional connection between ordered, living bone and surface of a load carrying implant[16].

For proper implant placement the available bone should be of adequate width and height. Various clinical and radiographic studies have proven that there must be changes in height and width of the alveolar bone after tooth extraction which results in insufficient vertical dimension or horizontal width of the alveolar ridge. The deficiency of alveolar ridge affects implant placement, implant stability and success of implants. The bucco-lingual ridge width can be evaluated by computed tomography, ridge mapping, trans-tomography, ultrasonography and direct caliper measurement following surgical exposure of the bone[7].

Various ridge augmentation procedures have been described for management of atrophic narrow maxillary and mandibular alveolar ridge including guided bone regeneration, onlay block bone grafting and distraction osteogenesis. These methods have drawbacks like higher cost, donor site morbidity and prolonged treatment period.

The ridge split procedure is a bone manipulation technique used to place implants in sites having bucco-lingual deficiencies[24]. Ridge split procedure was first

developed by Dr. Hilt Tatum in 1970s. This technique involves longitudinal osteotomy with the use of hand instruments, rotating burs or ultrasonic devices and create a green stick fracture. The ridge expansion can be done by using osteotomes, chisels or screw spreaders. Ridge split technique enables immediate implant placement which reduces the treatment time. Ridge split can be done by using traditional instruments like chisels, mallet and rotary instruments like burs. Rotary instruments are classified as low speed, high speed and ultra-speed based on its rpm. However, rotary instruments are very efficient in bone cutting; it has some disadvantages like soft tissue lacerations, loss of fine touch sensitivity and thermal injury. Overheating of adjacent tissues may alter or delay the healing response. These complications can be overcome by using ultrasonic device.

Piezosurgery was first introduced by Dr. Tomaso vercelloti in 1997 and the piezoelectric device was first developed by Mectron medical technology in 1998. It is a minimally invasive technique using less frequency ultrasonic waves (24 to 36 kHz) and vibrating inserts for more precise and less traumatic bone cutting. Various clinical and preclinical studies combined with in vitro studies have shown that piezosurgery produces clean and precise osteotomies with smooth walls and decreased bleeding[87].Ultrasonic bone surgery allows selective cutting only on mineralized tissue. During surgery it reduces patient's stress and fear by creating very less noise and vibrations. The advantages of piezosurgery are selective cutting action, micrometric cutting action and decreased bleeding due to cavitation effect and reduced postoperative discomfort.

Implant stability is one of the fundamental prerequisites for achieving successful osseointegration and it depends upon quantity and quality of local bone, the implant design and the surgical technique used[39]. Implant stability can be divided

into primary and secondary stability[53]. Primary stability is mainly attained by mechanical engagement of implant with cortical bone at the time of implant placement. Primary stability is higher just after implant placement due to mechanical compression of fixture of bony walls and it decreases with time. Secondary stability shall increase progressively and directly related to the biologic events at the bone-implant interface such as bone formation and remodeling[67]. The secondary stability is strongly influenced by fixture characteristics and surgical techniques.

Various diagnostic methods are available to check implant stability such as Surgeon's perception, imaging techniques, Percussion test, Insertion torque measurement, Seating torque, Reverse torque test, Impact hammer method, Periotest, Resonance frequency analysis and Pulsed oscillation wave form.

The Resonance Frequency Analysis (RFA) is one of the precise methods that provide objective and reliable measurements of lateral micro-mobility at various stages of implant process. Osstell is a commercially available RFA machine which has combined transducer, computerized analysis and the excitation source into one machine. This instrument records the resonance frequency analysis arising from the implant-bone interface and displays it graphically. The installed implant is connected to a frequency response analyzer through a piezo-electronic transducer. The oscillation of the implant – transducer element is recorded as the Implant Stability Quotient (ISQ), which represents a standardized unit of stability. The ISQ values seem not to be affected by instrument positioning, especially if two directional readings are performed, results are reliable and sensitive. The ISQ is recorded as a number between 1 and 100, the higher the ISQ value, the more securely the implant is presumed to be anchored in the bone.

Hence the aim of the study is to compare the implant stability, bucco-lingual width of the alveolar ridge and marginal bone loss around implants, after ridge split technique and implant placement using piezoelectric bone surgery and rotary instruments.

Aim &objectives

AIM

To compare the implant stability, bucco-lingual width of the alveolar ridge and marginal bone loss around implants, after ridge split technique and implant placement using piezoelectric bone surgery and rotary instruments.

OBJECTIVES

1. To examine the implant stability quotient (ISQ) value of the implants placed in conjunction with the ridge split technique using piezoelectric bone surgery and rotary instruments at the time of implant placement and after 3 months.
2. To identify changes in the bucco-lingual width of the alveolar ridge before ridge split using piezosurgery and rotary instruments, immediately after implant placement, and after 3 months using a surgical caliper and CBCT.
3. To compare the radiographic marginal bone level around implants at baseline (immediately after implant placement) and after 3 months.

Review of literature

Pietrokovski J, Massler M (1967)[64] conducted an animal study about the morphologic changes that occurs after a tooth extraction and the patterns of edentulous ridge formation following tooth extractions in the maxilla and mandible. Based on the results, they concluded that the buccal plate in the maxilla was resorbed to a greater extent than the palatal plate and the buccal plate in the mandible was resorbed more than the lingual plate. The amount of tissue resorption was significantly greater in the edentulous molar region than in the incisor and premolar regions of both jaws.

Albrektsson T, Brånemark PI, Hansson HA, Lindstrom J (1981)[5] performed a meticulous technique aiming at osseointegration-a direct contact between living bone and implant. The interface zone between bone and implant was investigated using X-rays, SEM, TEM and histology. The results stated that the technique of osseointegration is a reliable type of cement-free bone anchorage for permanent prosthetic tissue substitutes.

Simion M, Baldoni M, Zaffe D (1992)[75] performed a surgical technique involved splitting the alveolar ridge longitudinally in two parts, creating greenstick fracture. Two cortical plates were separated with chisel. Implants were placed and covered with polytetrafluoroethylene membrane. Biometric examination showed a gain in bone width. Histologic examination showed regeneration of bone tissue. Based on the outcomes they concluded that this membrane technique could be effective and predictable technique for horizontal augmentation associated with immediate implant placement.

Borgner RA, Kirkos LT, Gougaloff R, Cullen MT, Delk PL (1999)[15] investigated about bone expansion techniques and concluded that the bone expansion techniques showed significant improvement of atrophic arch morphology and reduced patient morbidity and cost of another surgical procedure.

Vercellotti T (2000)[86] reported a case about a new surgical technique called piezoelectric surgery which has modulated-frequency piezoelectric energy scalpels that permits the expansion of the ridge and the placement of implants in single stage surgery. The case report illustrates the ridge expansion and positioning of implants in atrophic ridge with only 2 to 3 mm thickness. After 3 months evaluation the results revealed that the treated site was mineralized and stabilized at a thickness of 5 mm and the implants were osseointegrated.

Hermann JS, Buser D, Schenk RK, Higginbottom FL, Cochran DL (2000)[43] evaluated the implantogingival junction of unloaded and loaded non-submerged titanium implants and conducted histometrical analysis. The results of the analysis indicated that the Biologic Width is a physiologically formed and stable structure over time in the case of non- submerged ,one piece titanium implants as evaluated histometrically under unloaded and loaded conditions.

Vercellotti T, De Paoli S, Nevins M (2001)[85] proposed a new surgical technique, piezoelectric bony window osteotomy that simplifies maxillary sinus surgery procedure. Piezoelectric bony window osteotomy and piezoelectric sinus membrane elevations were performed on 15 patients using piezoelectric surgical device. Results of the study stated that the technique results in 95% success rate.

Coatoam GW, Mariotti A (2003)[26] performed a surgical procedure for ridge expansion by means of splitting the crest of an edentulous ridge. Based on their study they revealed that the segmental ridge split procedure is an efficient method for expansion of an atrophic ridge which eliminating the need for a second surgical site.

Basa S, Varol A, Turker N (2004)[11] evaluated the effectiveness of a split crest bone augmentation technique performed for immediate implant placement in edentulous posterior mandibular ridges. In 30 patients 125 implants were placed in atrophic posterior mandibular ridges after ridge split procedure. Based on the results they concluded that the split crest surgical technique is a valid reconstructive procedure for sharp posterior mandibular ridges.

Vercellotti T, Nevins M.L, Kim D.M, Nevins M, Wada K, Schenk R.K et al (2005)[87] conducted a histological evaluation of postoperative wound healing response following surgical ostectomy and osteoplasty with piezosurgery compared to carbide bur or diamond bur . Results of the study revealed that the piezosurgery provided more favorable osseous repair and remodeling than carbide or diamond bur.

Guirado JL, Yuguero MR, Carrion del Valle MJ, Zamora GP (2005)[41] demonstrated a maxillary ridge-splitting technique followed by immediate placement of implants. Six 4mm wide by 13mm long threaded Osseotite implants were placed immediately within the split ridge and surrounded with a mixture of autogenous tuberosity and bovine bone. They concluded that this technique results in less surgical trauma and condensed treatment time.

Chiriac G, Herten M, Schwarz F, Rothamel D, Becker J (2005)[25] investigated the influence of a new piezoelectric device, designed for harvesting autogenous bone chips from intra-oral sites, on chip morphology, cell viability and differentiation. Within the limits of the study, they concluded that both the harvesting methods are not different from each other concerning their detrimental effect on viability and differentiation of cells growing out of autogenous bone chips derived from intra-oral cortical sites.

Schlee M, Steigmann M, Bratu E, Garg A.K (2006)[72] evaluated the performance of piezoelectric device and concluded that by using piezoelectric device, implantology surgical techniques such as bone harvesting, crestal bone splitting, and sinus floor elevation can be performed with greater ease and safety.

Blus C, Szmukler-Moncler S (2006)[14] evaluated a new technique using Ultra-sonic bone surgery device to perform ridge-split procedures. Based on the results, they concluded that the split-crest procedure performed with ultrasonic bone surgery device showed to be safe and comfortable.

Chiapsco M, Ferrini F, Casentini P, Accardi S, Zaniboni M (2006)[23] conducted a study to evaluate the capability of a new surgical device to widen narrow edentulous alveolar ridges and to allow correct placement of endosseous implants in horizontally atrophied sites. Based on the results of the study they concluded that the technique appeared reliable and simple, with reduction of morbidity and times of dental rehabilitation as compared with other techniques such as autogenous bone grafts and guided bone regeneration.

Enislidis G, Wittwer G, Ewers R (2006)[36] reported a staged approach to ridge splitting in the mandible to decrease the risk of malfracture during osteotomy procedure. The results of the study indicated that staged ridge splitting can be a safe technique which overcomes the problems associated with single-stage ridge expansion/ridge splitting procedures without causing significant delay in treatment.

Calvo Guirado JL, Pardo Zamora G, Saez Yuguero MR (2007)[19] performed a technique for widening the thin atrophic ridge by splitting the alveolar bone longitudinally and filling the bone gap with collagenised pig bone along with simultaneous implant placement. They reported that the technique results in less surgical trauma and reduced treatment time.

Belleggia F, Pozzi A, Rocci M, Barlattani A, Gargari M (2008)[12] assessed that split-crest procedure done by piezoelectric bone surgery allows the clinician to augment thin edentulous bone crests, even with a very mineralized ridge, and implants insertion in single-stage surgery. They concluded that piezoelectric ridge expansion technique permits to obtain the expansion of much mineralized bone crests without excessive traumas or the risk of ridge fractures.

Chen LC, Lundgren T, Hallström H, Cherel F (2008)[20] demonstrated a study to compare ridge-mapping measurement before surgical flap reflection and measurement using images from cone beam computerized tomography to direct caliper measurement following surgical exposure of the bone. 25 sites were measured with fabricated acrylic stent provided three buccal/lingual pairs of consistent measurement points for each implant site located 4, 7, and 10 mm from the summit of the alveolar soft tissue. Based on the results they concluded that CBCT was less consistent

compared to direct caliper measurements and did not provide any additional, significant diagnostic information.

Danza M, Guidi R, Carinci F (2009)[30] conducted a study on series of spiral implants inserted with or without piezoelectric surgery split crest. 234 spiral family implants were inserted in 86 patients, among these 21 implants were inserted into piezoelectric surgery split crest. Based on the results of the study they concluded that piezoelectric surgery split crests provide several advantages and clinical outcomes while compared with standard procedures.

Blus C, Szmukler-Moncler S, Vozza I, Rispoli L, Polastri C (2010)[13] underwent a 3 years follow-up study to evaluate ultrasonic bone surgery in split-crest procedures with immediate implant placement.61 split-crest procedures were performed, and 180 implants were placed in 43 patients. Results of this study revealed that the ultrasonic bone surgery is predictable to perform split-crest procedures without risk of bone thermo necrosis; it decreases the risk of soft tissue alteration.

Holtzclaw DJ, Toscano NJ, Rosen PS (2010)[44] performed a retrospective consecutive case series to assess the efficiency of piezoelectric hinge-assisted ridge split procedure for reconstruction of posterior mandibular alveolar ridge deficiencies. 13 patients with 17 horizontal alveolar ridge deficiencies of the posterior mandible were treated with the piezoelectric hinge-assisted ridge split procedure. The report of this study stated that the piezoelectric hinge-assisted ridge split procedure can achieve substantial gains in horizontal ridge width of the edentulous posterior mandible without associated morbidity.

Yoon HG, Heo SJ, Koak JY, Kim SK, Lee SY (2011)[88] investigated the influence of bone quality and surgical technique on the implant stability quotient (ISQ) value. They also assess the influence of interfacial bone quality, directly surrounding the implant fixture, on the resonance frequency of the structure was also evaluated by the finite element analysis. Based on the analysis they concluded that both the bone quality and surgical technique have influence on the primary implant stability, and resonance frequency has a positive relation with the density of implant fixture-surrounding bone.

Stacchi C, Vercellotti T, Torelli L, Furlan F, Di Lenarda R (2011)[78] investigated the stability changes of implants inserted using traditional rotary instruments or piezoelectric inserts. 20 patients received two identical, adjacent implants in the upper premolar area: the test site was prepared with piezosurgery, and the control site was prepared using twist drills. Resonance frequency analysis measurements were taken by a blinded operator on the day of surgery and after 7, 14, 21, 28, 42, 56, and 90 days. The findings of this study suggest that ultrasonic implant site preparation results in a limited decrease of ISQ values and in an earlier shifting from a decreasing to an increasing stability pattern, when compared with the traditional drilling technique.

Sunilkumar N, Sowmya N (2012)[80] performed ridge split technique in mandibular atrophic ridge using piezoelectric device along with implant placement. Based on the outcomes they concluded that piezosurgical ridge expansion technique is a minimally invasive, safe and promising technique which can be applied in all advanced and complicated cases.

Kelly A, Flanagan D (2013)[48] demonstrated an edentulous ridge expansion with the use of piezosurgery and immediate placement of implants. They found that edentulous ridge expansion with a piezosurgery device and motorized expansion screws for immediate implant placement may be a predictable surgical technique that is safe, less technique sensitive, and without significant risk of soft tissue injury.

da Silva Neto UT, Joly JC, Gehrke SA (2014)[29] performed a study to evaluate the implant stability quotient of dental implants that were installed in sites prepared by either conventional drilling or piezoelectric tips. The stability of each implant was measured by resonance frequency analysis immediately after placement to assess the immediate stability. The results shows that stability of implants placed using the piezoelectric method was greater than that of implants placed using the conventional technique.

Ayoub AH (2014)[9] reported a case of severe maxillary alveolar atrophy in incisor area during placement of an immediate taper-shaped implant associated with a ridge widening procedure with non-traumatic expanders. They assessed that this technique results in 4mm gain in width and perfect implant stability and its recommended to be used in rehabilitation of deficient atrophic ridges.

Chiang T, Roca AL, Rostkowski S, Drew HJ, Simon B (2014)[21] demonstrated a ridge split technique with vertical bone incisions for expansion and mobilization of the buccal plate, creating a space that will contain the particulate graft material. The use of piezoelectric surgery enables a precise crestal bony incision in severely deficient ridge widths and aids in faster wound healing. This study concluded that the ridge split technique with piezoelectric surgery enhances the predictability of horizontal bone gain with reduced surgical trauma and postoperative complications.

Nandal S, Ghalaut P, Shekhawat H (2014)[60] performed a study to determine the marginal bone level changes around dental implants based on the radiological examination and they also evaluated the relationship of various parameters such as gender, implant length, implant diameter and location of implants on the amount of bone loss around dental implants. Results of this study stated that bone loss was found to be same in both maxilla and mandible on both mesial and distal aspects of implants. Bone loss was found to be more in females on both mesial as well as distal aspects of implants.

Papathanasiou I, Vasilakos G, Baltiras S, Zouloumis L (2014)[62] reported with 2 interesting clinical cases with narrow alveolar ridges treated with the ridge splitting technique and immediate implant placement. They found that the ridge splitting technique seems to be a minimally invasive option for horizontal augmentation of narrow alveolar ridges.

Patil PG, Nimbalkar-Patil S (2015)[63] described a technique to evaluate the crestal bone loss to assess implant success rate with radiographs and/or computerized tomography. Conventionally, the distance between the first screw thread to the top of the alveolar crest in the parallel periapical radiograph is measured to assess crestal bone changes. To minimize the measurement errors they propose a new method to measure a crestal bone level from the tip of the implant body instead of first screw thread.

Ajanovic M, Hamzic A, Redzepagic S, Cesir AK, Kazazic L and Tosum S (2015)[4] analyzed the crestal bone resorption around dental implants in different regions of maxilla and mandible after one year of functional loading. The results of this study shows that there is more crestal bone loss seen in anterior implants compared to

posterior ones, but there was no significantly different crestal bone loss between maxillary and mandibular implants regarding sites, after one year of functional loading.

Mootha A, Malaiappan S, Varghese S, Jayakumar N D, Karthikeyan G (2015)[58] compared direct intraoperative ridge measurements using vernier calipers to measurements taken by alveolar ridge mapping, Computed Tomography and Cone-Beam Computed Tomography for measuring alveolar bone dimensions prior to implant placement. They prepared an acrylic stent for providing consistent measurements of alveolar ridge dimensions through ridge mapping. A conventional CT and CBCT were taken and these three techniques were compared to direct intraoperative ridge measurements. Based on the results they concluded that Ridge mapping can be used effectively for measurement of alveolar bone width. Additional information about the surgical site can be obtained from a conventional CT or a CBCT.

Anitua E, Alkhraisat MH (2016)[8] performed a retrospective study to assess the long-term outcomes of the alveolar ridge split procedure and to evaluated the intraoperative and postoperative complications. Based on this study they concluded that the alveolar ridge split is an effective for horizontal bone augmentation in the mandible.

Longoni S, Maroni I, Baldini A, Sartori M (2016)[50] conducted a radiographic study on marginal bone changes in implants placed with split crest technique in the maxillary latero-posterior area. After a mean period of 6.2 years of functional implant survival and success rates were assessed. Based on the results they stated that

implants inserted in conjunction with split crest technique as a promising therapy with similar results as conventional implant surgery.

Verardi S, Pastagia J (2017)[84] conducted a split mouth study to compare the patient perception while doing osseous resective surgery in treatment of chronic periodontitis with traditional rotary instruments and piezoelectric bone surgery. Test sites were operated using piezoelectric bone surgery and control sites with traditional instruments in two separate sessions. Patients were asked to evaluate their perception of cold sensitivity, spontaneous pain, bleeding, swelling, and chewing discomfort. Based on the patient's response this study revealed that piezoelectric bone surgery seems to be well tolerated than conventional rotary instruments.

Dave BH, Sutaria S, Mehta S, Shah P, Prajapati T, Asnani M (2017)[31] compared the techniques such as ridge mapping, direct surgical exposure, and cone beam computed tomography which are used to measure the alveolar ridge bone width and determine their accuracy in the clinical application. Based on this study they stated that there is no significant difference in these techniques used to evaluate the width of the alveolar ridge.

Moro A, Gasparini G, Foresta E, Saponaro G, Falchi M, Cardarelli L et al (2017)[59] conducted a study to determine the reliability of piezo tips that have been specifically designed for the treatment of atrophic ridges and evaluated the amount of horizontal and vertical bone gain achieved by means of a two-step piezosurgical split technique. Results of this study stated that the piezosurgical split technique is a safe, simple and effective technique which allows obtaining ideal positioning of implants.

Bruschi GB, Capparé P, Bravi F, Grande N, Gherlone E, Gastaldi G et al (2017)[17] performed a study to assess the radiographic bone level changes of implants placed by the split crest procedure both in maxilla and mandible. Based on the results of this study they revealed that the marginal bone stability is influenced by blood supply on different flap approaches and suggests that a full thickness flap should not be reflected when ridge splitting is done.

Jha, N., Choi, E. H., Kaushik, N. K., & Ryu, J. J (2017)[46] evaluated the instrumentation procedures of the alveolar ridge expansion technique with or without Guided Bone Regeneration and its outcome. Based on the review they concluded that the motorized expanders and ultrasonic surgery system are easier to use and less traumatic while compared to the traditional instruments like mallets and osteotomes.

Ramal A, Masri ME, Shokry M, Attia N (2018)[69] investigated whether the modified ridge split technique be as effective as the conventional staged approach for horizontal augmentation of narrow posterior mandible. They assessed parameters like pain using visual analog scale, edema using tape measuring method, healing and radiographic measurements of buccolingual crestal bone width at pre-operative, immediately postoperative, and 6 months post-operative. Based on the outcomes they concluded that the modified ridge split technique in posterior mandible is a simple and predictable procedure with satisfactory results.

Materials & methods

STUDY DESIGN

A total of 10 sites among 5 patients of both gender (3 males, 2 females), aged between 25-50 years, who reported to the Department of Periodontology and Implant Dentistry, CSI College of Dental Sciences and Research, Madurai with bilateral edentulous site in posterior atrophic mandible were selected for the study.

A split mouth design was used, so that each patient acted as their own control. One quadrant on each side was randomized to the two treatment sites. Sites were randomly selected by lot system.

All the patients were informed about the whole surgical procedure and a detailed informed consent form was obtained. The study was approved by the Institutional ethical committee of CSI College of Dental Sciences and Research, Madurai. (IEC/0019/2016).

INCLUSION CRITERIA

- >18 years of age
- Presence of bilateral posterior thin mandibular alveolar ridges missing atleast 1- 3 teeth
- Bucco-lingual ridge dimension of ≤ 3.5mm
- Minimum bone height of 10mm in edentulous sites
- Adequate interocclusal distance for implant placement
- Systemically healthy patients
- Patients who maintain satisfactory oral hygiene

EXCLUSION CRITERIA

- Smoking or use of tobacco and betel nut in any form
- Pregnant women and lactating mother
- Patient under radiation therapy to head and neck
- Patient under bisphosphonate therapy
- Patients with history of uncontrolled coagulation disorders or metabolic diseases
- Patients with habit of alcohol or drug abuse

PARAMETERS OBSERVED

- Implant stability (in ISQ and in Ncm)
- Bucco-lingual width of the alveolar ridge (in mm)
- Radiographic crestal bone loss around implants (in mm)

MATERIALS

Surgical materials used were Disposable surgical gloves, Disposable mouth mask, Mouth mirror, Explorer, Tweezer, Lignocaine hydrochloride 2% with adrenaline, Bard parker Blade handle, Bard parker Blade No: 15, Periosteal elevator, Castroviejo caliper 40 mm, Osteotome chisels 2mm and 3 mm, Silicon Mallet, Tapered fissure carbide bur (701), Piezosurgical unit (NSK®), Physiodispenser (Osseoset® 200), Micromotor hand piece, Implants (NORIS®), Universal hand wrench, Osstell® - Resonance frequency analysis, BIO-OSS®-Bone graft, NOVATAPE®-Resorbable collagen membrane, Scissors, Suture material (Ethicon) and Needle holder.

IMPLANT DESIGN

In this study we used 10 internal hex titanium implants (NORIS® Medical Ltd) in sizes of

- 3.75mm diameter and length of 11.5mm- 4nos
- 3.75mm diameter and length of 10mm- 4nos
- 4.2mm diameter and length of 11.5 mm- 2nos

METHODS

After completion of scaling, the mandibular edentulous sites were divided into control and test site.

Control site	Test site
Ridge split and implant site preparation done using rotary instruments	Ridge split and implant site preparation done using piezoelectric bone surgery

TREATMENT PROTOCOL

Pre surgical evaluation:

Presurgical clinical examination was performed for all patients. Case history which included detailed medical history and dental history, were recorded. Study models were prepared after taking impression of maxillary and mandibular arches. After complete blood investigation, Cone Beam Computed Tomography (CBCT) and Orthopantamogram (OPG) were taken for all patients to verify the available bucco-lingual width of the edentulous sites.

SURGICAL PROCEDURE

All surgeries were performed under aseptic conditions. Following administration of local anesthesia (Lignox 2% A containing 1:80,000 adrenaline), a crestal incision was made on the control and test sites and a crevicular incision was given in relation to adjacent teeth by using No-15 Bard Parker blade. Full-thickness mucoperiosteal flap was raised using a periosteal elevator, the underlying bone was exposed and bucco-lingual dimension of the ridge was directly measured with Castroviejo caliper (40 mm).

Control site

Corticotomy cuts were given by using tapered fissure carbide bur (701) with diameter of 1.2mm. Crestal horizontal cut were made at mid crest extending 5 to 8mm subcrestally and 1mm from the adjacent tooth. Subsequently, 2 vertical cuts were made on buccal cortical plate of edentulous site to mobilize the buccal plate. No 2 and 3 osteotomes were used to expand the space for implant placement. Implant site preparation was performed with rotary drills.

Test site

Corticotomy cuts were given by using piezoelectric device with surgical tip OT7 (NSK®). Crestal horizontal cut were made at mid crest extending 5 to 8 mm subcrestally and 1mm from the adjacent tooth. Subsequently, 2 vertical cuts were made on buccal cortical plate of edentulous site to mobilize the buccal plate. No 2 and 3 osteotomes were used to expand the space for implant placement. Implant site preparation was performed with specific piezo electric inserts **SG15A, SG15B, SG16A, and SG16B** (NSK®).

Manufacturer recommendations were followed for sequence of drills and piezo electric inserts in preparing implant osteotomy sites. Implants with same diameter and length were placed on both control and test sites.

Implant stability was assessed using universal hand torque wrench and by using Osstell® device. Immediately after implant placement, ridge width was measured using Castroviejo caliper. Bone graft (Bio-Oss®) was placed into the intraosseous bone space created with the ridge split procedure and lateral to the mobilized buccal plate. A resorbable collagen membrane was placed to contain the bone graft material. Surgical site was approximated by 3-0 Black silk (Ethicon). Post-operative instructions were given.

POST-OPERATIVE INSTRUCTIONS

Medications

Patients were prescribed with Amoxicillin 500 mg (Mox) capsules every 8 hrs for 3 days, Aceclofenac 100 mg + Paracetamol 325 mg (Acenac-P) tablets every 8 hrs for 3 days, Chymorol forte (Trypsin: Chymotrypsin) tablets every 12 hrs for 3 days, Pantoprazole 40mg (pan 40) tablets every 8 hrs for 3 days. Mouth rinse (Betadine) was prescribed and advised to continue till suture removal.

Instructions

Patients were requested to take soft and cold diet for 24 hours after surgery and to gargle with Betadine mouthwash every 8 hrs from second day till 1 week. Patients were recalled after 7 days for suture removal.

POSTOPERATIVE EVALUATION

- Suture removal was done after 7 days.
- All patients were followed for 1 week postoperatively then on intervals of 1 and 3 months respectively.

RESONANCE FREQUENCY ANALYSIS (RFA)

RFA were made on each implant on the day of implant placement and on 3 month after implant placement by using Osstell device. The frequency response of the system was measured by attaching the smart peg to the implant. The average of ISQ values was taken.

CLINICAL EVALUATION OF BUCCO-LINGUAL WIDTH

Bucco-lingual width of the edentulous site was directly measured on the day of surgery before and after ridge splitting by using castroviejo caliper (40 mm). During 3rd month follow up, after administration of local anesthesia bucco-lingual width was measured using castroviejo caliper.

RADIOGRAPHIC ASSESSMENT

1. Radiographic evaluation of bucco-lingual width of alveolar ridge.
2. Radiographic examination of crestal bone loss around implants.

1. Radiographic evaluation of bucco-lingual width of alveolar ridge.

Radiographic evaluation was performed after 3 months to measure the bucco-lingual crestal bone width at the center of the implants by CBCT. The results were compared with the pre-operative baseline measurements.

2. Radiographic examination of crestal bone loss around implants.

Radiographic examination of crestal bone loss was carried out using OPG taken with 20% magnification. These examinations were done on the day of implant placement and on 3 months after implant placement. The implant shoulder and alveolar crest used as reference points. Measurements were performed at mesial and distal aspects of implants digitally using digital imaging software (SIDEXIS XG®). Crestal bone loss was analyzed by calculating the difference between the measured bone levels in radiographs on the day of surgery and 3 months after surgery.

SOFT TISSUE ASSESSMENT:

Soft tissue healing in the surgical sites were assessed by evaluating the color change in tissues, patient's response on palpation, presence or absence of granulation tissue, degree of epithelialization in incision margins and presence or absence of suppuration. Careful inspection of surgical site was performed to detect any bone graft material or membrane exposure. The soft tissue evaluation was done on the next day of surgery, on 7th day and after 1 month.

FIGURE 1: ARMAMENTARIUM

FIGURE 2: SURGICAL ARMAMENTARIUM

FIGURE 3: PIEZOSURGERY UNIT (NSK®)

FIGURE 4: PIEZO TIPS

FIGURE 5: PHYSIODISPENSER (Osseoset® 200)

FIGURE 6: ROTARY DRILLS and HANDWRENCH

FIGURE 7: MALLET

FIGURE 8: OSTEOTOME CHISEL 2 mm & 3 mm

FIGURE 9: CASTROVIEJO CALIPER 40 mm

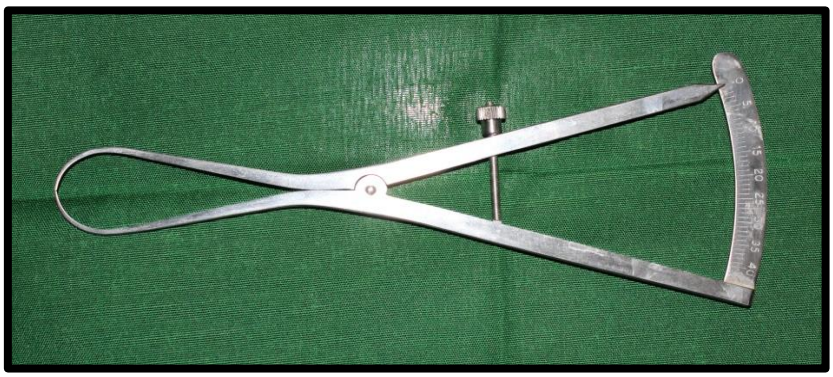

FIGURE 10: MICROMOTOR HAND PIECE

FIGURE 11: TAPERED FISSURE CARBIDE BUR (701)

FIGURE 12: IMPLANT (NORIS®)

FIGURE 13: OSSTELL®

FIGURE 14: BONE GRAFT (BIO-OSS®)

FIGURE 15: RESORBABLE MEMBRANE (NOVATAPE®)

FIGURE 16: PRE OPERATIVE OCCLUSAL VIEW

IV QUADRANT-CONTROL SITE

Figure 17: Crestal and crevicular incision given.

Figure 18: Full thickness flap raised.

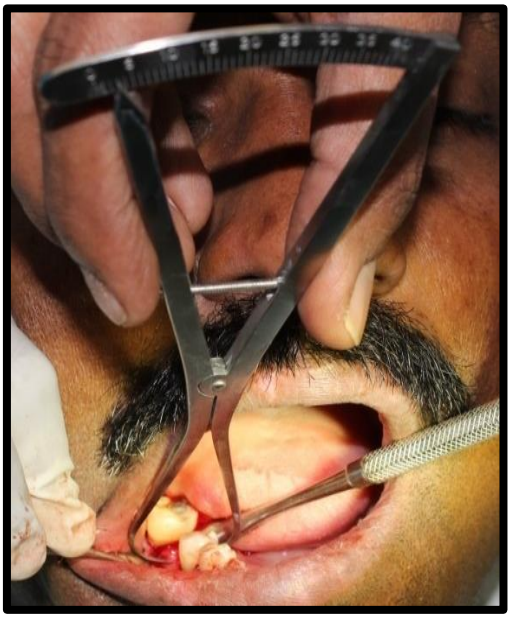

Figure 19: Direct ridge width measurement taken using surgical caliper

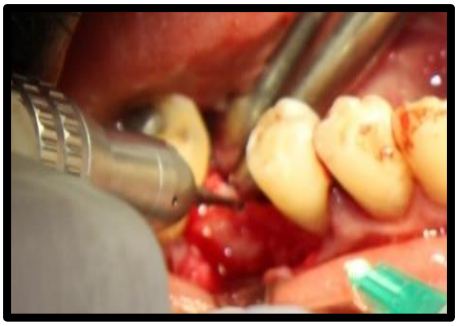

Figure 20: Ridge split done using rotary bur (701)

Figure 21: crestal and vertical bone incisions given using rotary bur (701)

Figure 22: Ridge expansion done with chisel and mallet

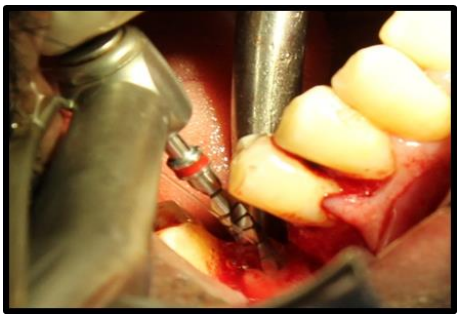

Figure 23: Implant site osteotomy done using rotary

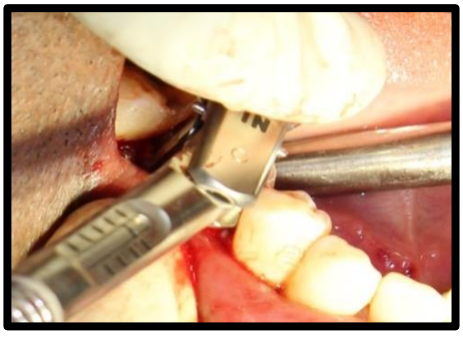

Figure 24: Implant stability measured using universal torque wrench

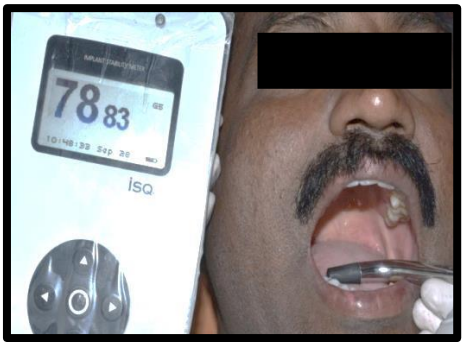

Figure 25: Implant stability measured using Osstell device

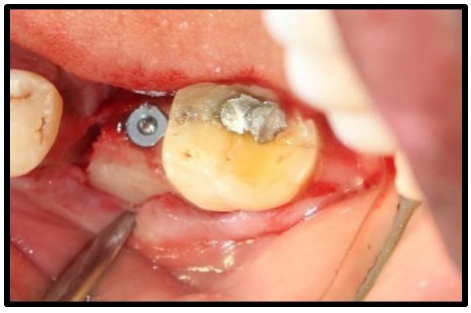

Figure 26: Implant placed

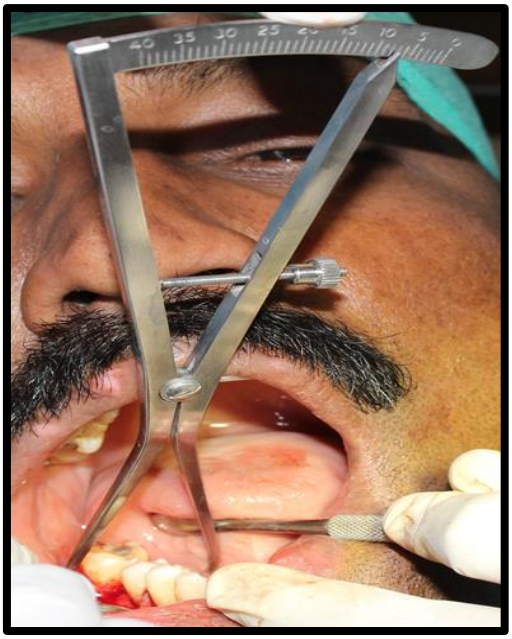

Figure 27: Ridge width measured after implant placement using surgical caliper

Figure 28: Bone graft placed

Figure 29: Membrane placed

Figure 30: Simple interrupted sutures placed

III QUADRANT-TEST SITE

Figure 31: Crestal and crevicular incision given

Figure 32: Full thickness flap raised

Figure 33: Direct ridge width measurement taken using surgical caliper

Figure 34: Ridge split done by using piezoelectric device (OT7)

Figure 35: Crestal and vertical bone incisions given using piezoelectric device (OT7)

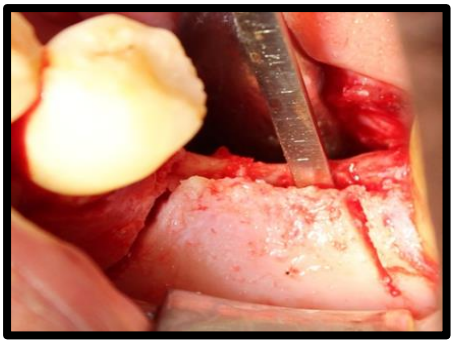

Figure 36: Ridge expansion done with chisel and mallet

Figure 37: Implant site osteotomy done using piezo tips

Figure 38: Implant stability measured using universal torque wrench

Figure 39: Implant stability measured using osstell device

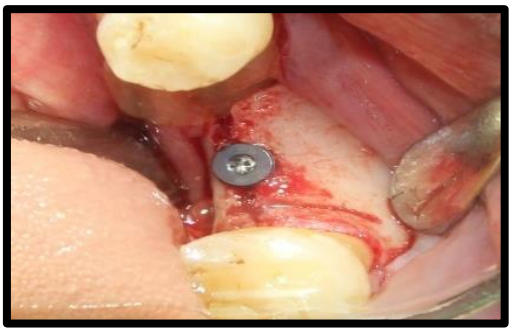

Figure 40: Implant placement done

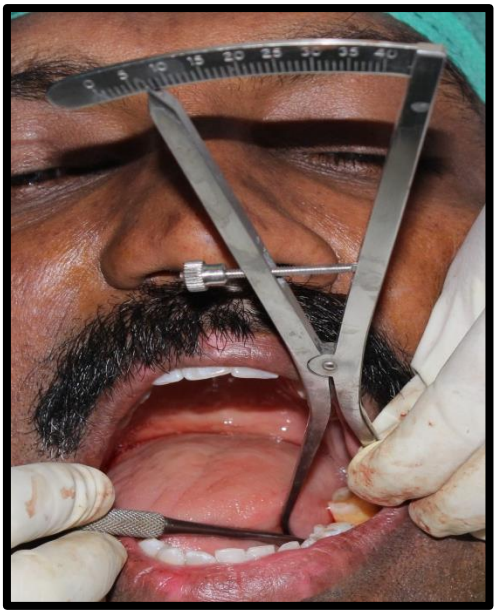

Figure 41: Ridge width measured after implant placement using surgical caliper

Figure 42: Bone graft placed

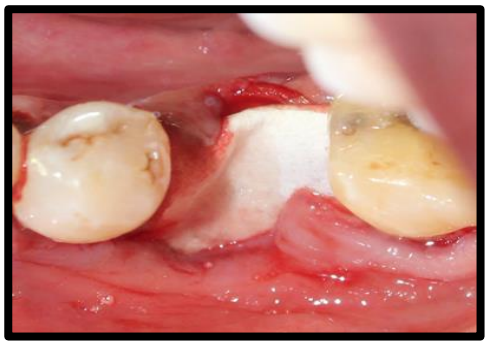

Figure 43: Membraneplaced

Figure 44: Simple interrupted sutures placed

Figure 45:1 Day post perative

Figure 46: 1Month post perative

Figure 47: 3 Months post operative

Figure 48: Impression made

Figure 49: After crown placement

Statistical analysis

STATISTICAL ANALYSIS

In this study the statistical evaluation was performed by using **SPSS software (version 22)**. Mean value and standard deviation were used to compare implant stability, bucco-lingual dimension of ridge and marginal bone loss over time for the piezosurgical procedure and rotary technique. Comparisons between both the techniques were performed using Mann -Whitney test. Difference was considered significant when $p < 0.05$.

Results

Table 1

MEAN AND STANDARD DEVIATION OF CLINICAL (SURGICAL CALIPER) BUCCO-LINGUAL WIDTH MEASUREMENT OF THE RIDGE DURING PRE-OPERATIVE, IMMEDIATELY AFTER IMPLANT PLACEMENT AND AFTER 3 MONTHS IN TEST AND CONTROL SITES.

	Pre-operative			**Immediately after implant placement**			**After 3 months**		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Test (N=5)	3.2	3-3.5	0.27	6.0	6	0.0	5.0	5	0.0
Control (N=5)	3.1	3-3.5	0.22	5.8	5.5-6	0.27	5.0	5	0.0
Mann-Whitney test	10.00			7.50			12.5		
p-value	0.513			0.134			1.0		

Graph 1

MEAN AND STANDARD DEVIATION OF CLINICAL (SURGICAL CALIPER) BUCCO-LINGUAL WIDTH MEASUREMENT OF THE RIDGE DURING PRE-OPERATIVE, IMMEDIATELY AFTER IMPLANT PLACEMENT AND AFTER 3 MONTHS IN TEST AND CONTROL SITES

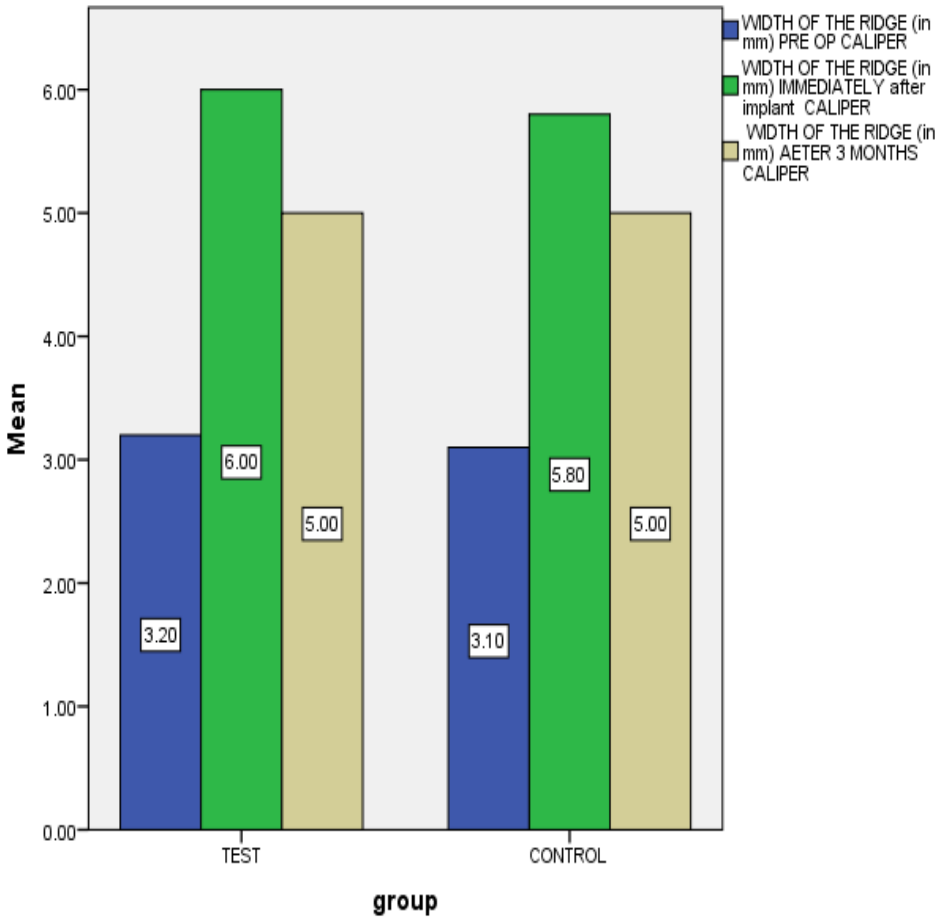

Table 1 and Graph 1 show the Mean and SD of clinical Bucco-lingual width measurements of the ridge during Pre-operative, Immediately after implant placement and after 3 months.

The Mean and SD values of clinical bucco-lingual width of the ridge during Pre-operative were 3.2mm ± 0.27 in Test sites. There was 2.8mm, 1.8mm increase in the bucco-lingual width immediately after implant placement and after 3 months respectively.

The Mean and SD values of clinical bucco-lingual width of the ridge during Pre-operative were 3.1mm ± 0.22 in Control sites. There was 2.7 mm, 1.9mm increase in the bucco-lingual width immediately after implant placement and after 3 months respectively.

The mean change in the clinical bucco-lingual width measurement among test and control sites immediately after implant placement and after 3 months was not statistically significant (p value > 0.05).

Table 2

MEAN AND STANDARD DEVIATION OF RADIOGRAPHIC (CBCT) BUCCO-LINGUAL WIDTH MEASUREMENT OF THE RIDGE DURING PRE-OPERATIVE AND AFTER 3 MONTHS IN TEST AND CONTROL SITES.

	Pre-operative (in mm)			**After 3 months (in mm)**		
	Mean	Range	SD	Mean	Range	SD
Test (N=5)	3.2	3.2-3.4	0.08	5.4	5.21-5.6	0.14
Control (N=5)	3.1	3.1-3.4	0.13	5.07	4.8-5.4	0.23
Mann-Whitney test	5.5			1.5		
p-value	0.131			0.021		

Graph 2

MEAN AND STANDARD DEVIATION OF RADIOGRAPHIC (CBCT) BUCCO-LINGUAL WIDTH MEASUREMENT OF THE RIDGE DURING PRE-OPERATIVE AND AFTER 3 MONTHS IN TEST AND CONTROL SITES

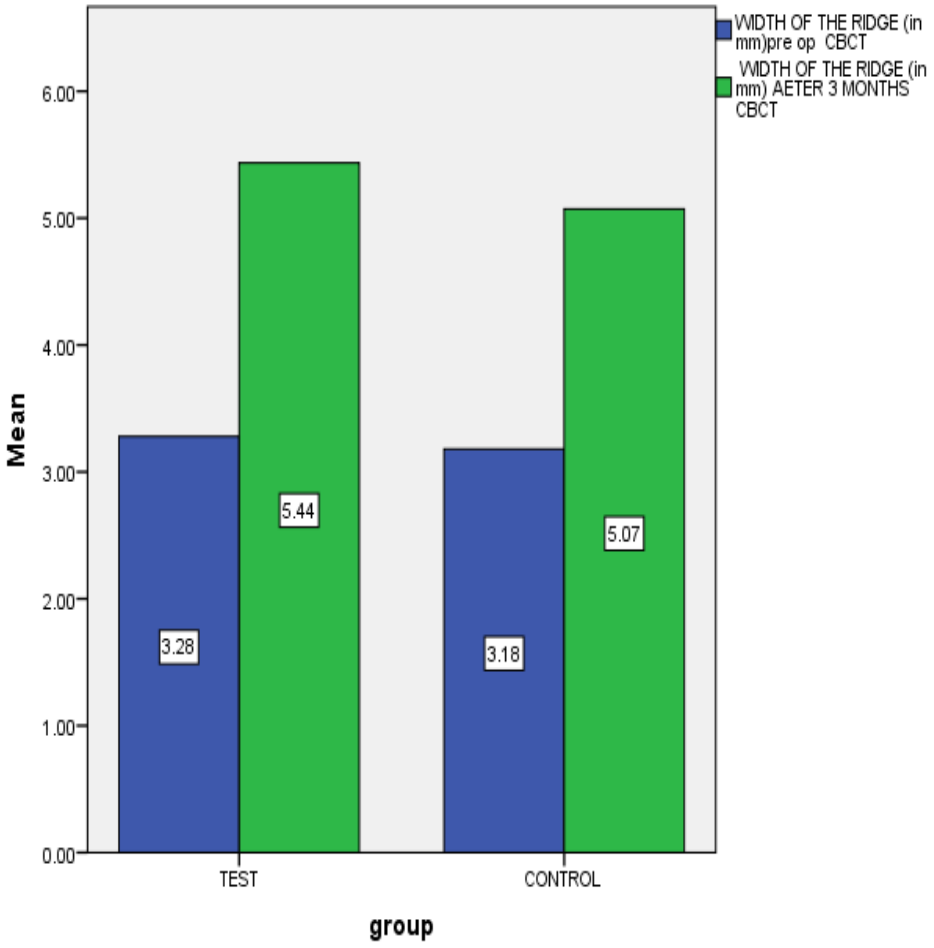

Table 2 and Graph 2 show the Mean and SD values of Bucco-lingual width of the ridge during Pre-operative and after 3 months.

The Mean and SD values of pre-operative radiographic Bucco-lingual width were 3.2mm ± 0.08 in Test sites. There was 2.2 mm increase in the bucco-lingual width after 3 months.

The Mean and SD values of pre-operative radiographic Bucco-lingual width were 3.1mm ± 0.13 in control sites. There was 1.97mm increase in the bucco-lingual width after 3 months.

The mean change in the radiographic bucco-lingual width measurement among test and control sites after 3 months was statistically significant (p-value 0.021).

Table 3

COMPARISON OF MEAN AND STANDARD DEVIATION OF RADIOGRAPHIC (CBCT) MEASUREMENT OF BUCCO-LINGUAL WIDTH OF THE RIDGE AND CLINICAL (SURGICAL CALIPER) BUCCO-LINGUAL WIDTH MEASUREMENT OF THE RIDGE DURING PRE-OPERATIVE AND AFTER 3 MONTHS**.**

	Pre-operative (in mm)						**After 3 months (in mm)**					
	Caliper			**CBCT**			**Caliper**			**CBCT**		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Test (N=5)	3.2	3-3.5	0.27	3.2	3.2-3.4	0.08	5.0	5	0.0	5.04	5.21-5.6	0.14
Control (N=5)	3.1	3-3.5	0.22	3.1	3.1-3.4	0.13	5.0	5	0.0	5.07	4.8-5.4	0.23
Mann Whitney test	10.0						.000					
p-value	0.594						0.005					

Graph 3

COMPARISON OF MEAN AND STANDARD DEVIATION OF RADIOGRAPHIC (CBCT) MEASUREMENT OF BUCCO-LINGUAL WIDTH OF THE RIDGE AND CLINICAL (SURGICAL CALIPER) BUCCO-LINGUAL WIDTH MEASUREMENT OF THE RIDGE DURING PRE-OPERATIVE AND AFTER 3 MONTHS

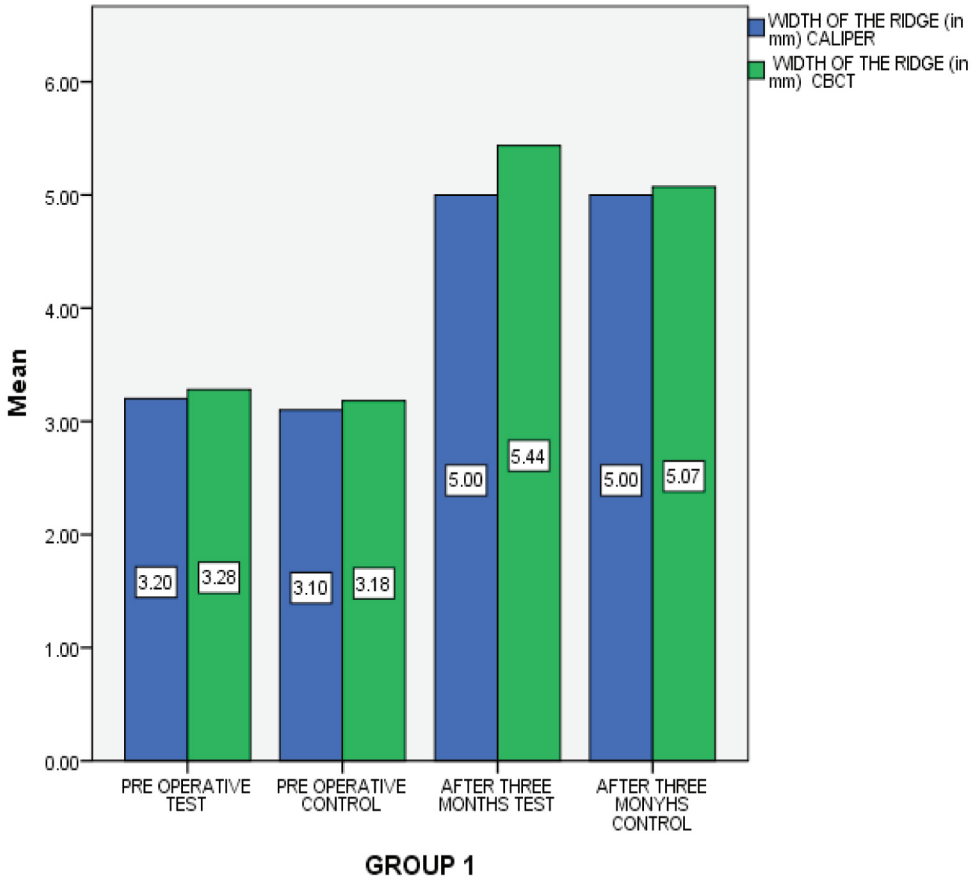

Table 3 and Graph 3 shows comparison of Mean and SD values of radiographic (CBCT) and the clinical (Surgical caliper) measurement of bucco-lingual width of the ridge during pre-operative and after 3 months

On comparing radiographic (CBCT) and clinical (surgical caliper) measurements, the mean change of the bucco-lingual width after 3 months among test and control sites was highly significant (p-value 0.005) which was more accurately done using CBCT while compared to the clinical measurements evaluated using caliper.

Table 4

MEAN AND STANDARD DEVIATION OF ISQ VALUES OF IMPLANTS IMMEDIATELY AFTER PLACEMENT AND AFTER 3 MONTHS IN TEST AND CONTROL SITES.

	Immediately after implant placement			**After 3 months**		
	Mean	Range	SD	Mean	Range	SD
Test (N=5)	68	60-80	8.3	77.7	67-83.5	6.3
Control (N=5)	60.8	52-74	9.0	65.9	53-82	11.2
Mann-Whitney test	7.0			5.0		
p-value	0.243			0.116		

Graph 4

MEAN AND STANDARD DEVIATION OF ISQ VALUES OF IMPLANTS IMMEDIATELY AFTER PLACEMENT AND AFTER 3 MONTHS IN TEST AND CONTROL SITES

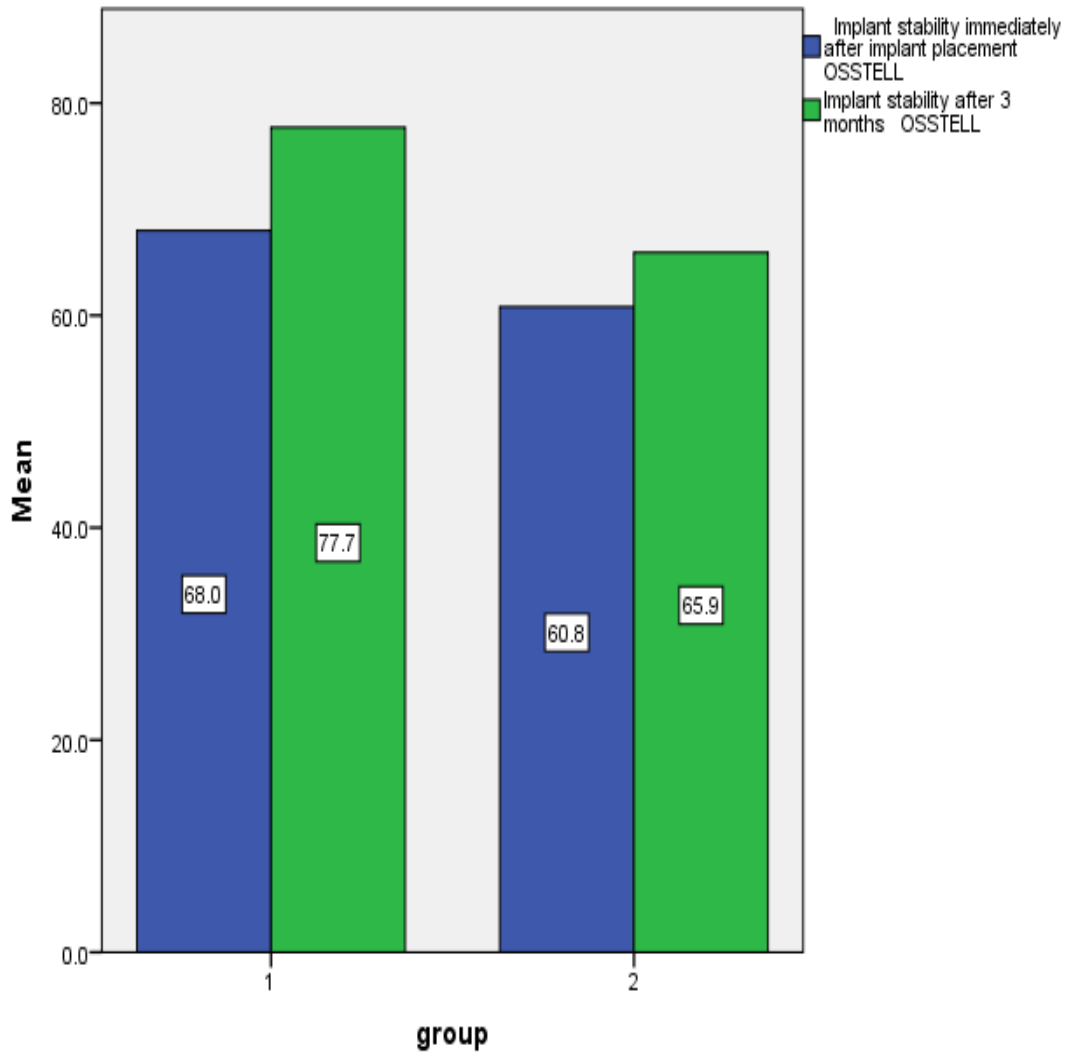

Table 4 and Graph 4 shows the Mean and SD of ISQ values of implants immediately after their placement and after 3 months.

The mean change in the ISQ value of implants immediately after their placement and after 3 months was 9.7 in the test sites and 5.1 in the control sites respectively.

The mean difference in the ISQ value immediately after implant placement among test and control sites was not statistically significant. (p value > 0.05)

The mean difference in the ISQ value after 3 months of implant placement among test and control sites was not statistically significant. (p value > 0.05)

Table 5

MEAN AND STANDARD DEVIATION OF RADIOGRAPHIC BONE LEVEL AROUND IMPLANTS IMMEDIATELY AFTER PLACEMENT AND AFTER 3 MONTHS IN TEST AND CONTROL SITES.

	Mesial			**Distal**			**Mesial**			**Distal**		
	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
Test (N=5)	1.04	0.06-1.96	0.73	1.04	0.04-1.75	0.70	2.06	0.93-3.09	0.83	1.9	1.02-2.85	0.78
Control (N=5)	0.55	0.07-0.92	0.38	0.37	0.08-0.78	0.27	1.5	0.52-3.09	1.03	1.4	0.47-2.39	0.77
Mann – Whitney test	9.0			6.0			7.5			8.0		
p-value	0.465			0.175			0.295			0.347		

Graph 5

MEAN AND STANDARD DEVIATION OF RADIOGRAPHIC BONE LEVEL AROUND IMPLANTS IMMEDIATELY AFTER PLACEMENT AND AFTER 3 MONTHS IN TEST AND CONTROL SITES

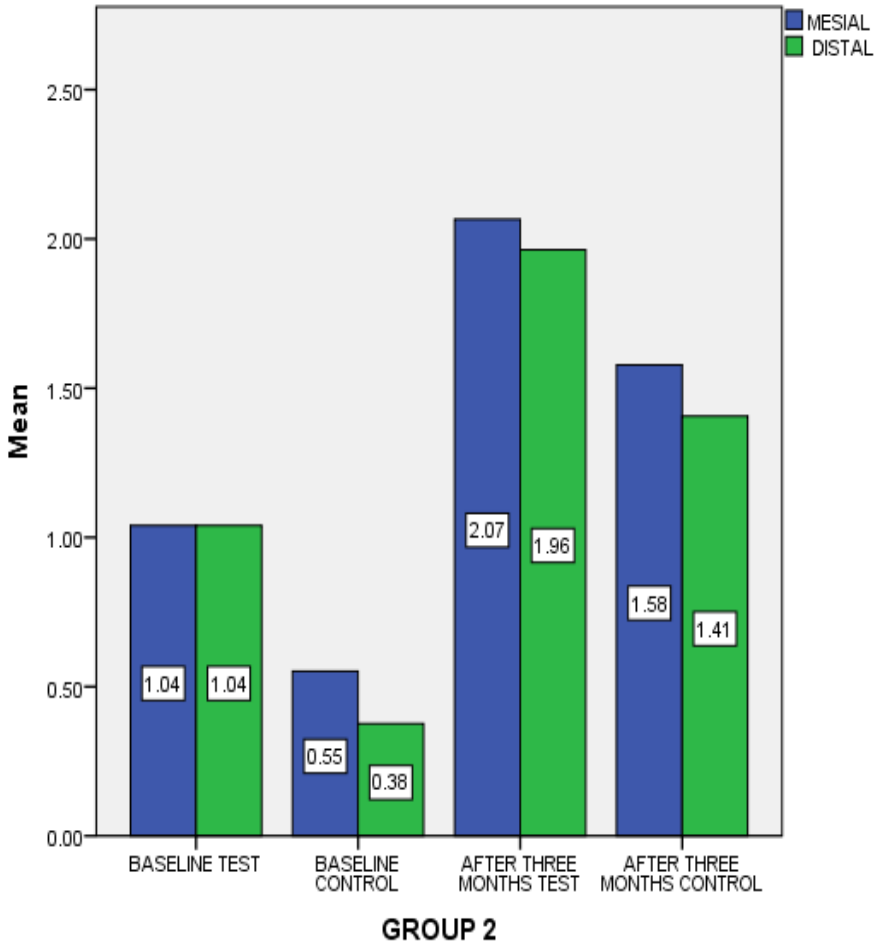

Table 5 and Graph 5 shows the Mean and SD values of recorded bone level on mesial and distal aspects of implants immediately after their placement and after 3 months.

The mean values of recorded bone level around mesial and distal aspects of implants immediately after their placement and after 3 months among test and control sites was not statistically significant (p value > 0.05).

Discussion

Dental implant has revolutionized the field of dentistry and rehabilitation of missing teeth with dental implants is considered far more efficient than conventional fixed prosthesis. It all started in 1950's -1960's with the studies of a Swedish orthopedic surgeon Professor P. I. Brånemark who proposed and developed landmark studies of bone healing and regeneration around implants. Professor P. I. Brånemark called this structural and functional connection between bone and implant as "osseointegration".

The utmost aim of any implant treatment is to achieve not only a functional and structural predictability and also long term stability. It's been reported that the success rate of implants was improved by modifying the implant surfaces, by various surgical techniques and by modifying the bone which needs implant.

Earlier, Dental Implant placement was done only if there was sufficient height, width and angulation was evident. But, immediately after extraction, there is a rapid loss of alveolar bone either leading to horizontal or vertical ridge deficiency. The field of implant dentistry faced an upteam challenge to provide satisfactory replacement in patients with atrophic alveolar ridges with acceptable results. It is shown in the literature that, of all sites in oral cavity, posterior mandible is referred as difficult site for reconstruction both horizontally and vertically.

When the horizontal width of the alveolar ridge is deficient, additional bone augmentation procedures are needed in order to reconstruct the deficient alveolar ridge. The bone augmentation procedure that has been advocated, include guided bone regeneration (Nevins M & Mellonig JT 1992[61], Hammerle et al 2002[42]) with particulate graft, block grafts (Marx RE et al 1998[51], Chiapasco M et al 1999[22]) obtained from ramus, symphysis, iliac crest or calvarial bone and ridge split

procedure. The major disadvantage of onlay bone grafts are its invasiveness, an additional donor site and resorption of grafted bone. The disadvantages associated with guided bone regeneration are exposure and collapse of the membrane.

To overcome these limitations, alveolar ridge split technique is reported to be a minimally invasive technique, which is used to expand the ridge for creating an adequate space for placement of implants. Ridge split technique was first described by Hilt Tatum (1986)[82] and later modified by Scipioni A, Bruschi GB (1994)[73]. Aghaloo TL et al (2007)[3] suggested that the ridge split technique is an effective way to solve the problem of the width in narrow ridges with adequate height. Coatoam GW et al (2003)[26] reported that the ridge split procedure is an efficient method for expansion of an atrophic ridge which eliminates the need for a second surgical site.

Early techniques of ridge expansion were performed either with chisel, air driven rotary hand pieces and oscillating saws. Even though the rotary instruments have advantages like speed and efficiency, it has some disadvantages like soft tissue injury and thermal necrosis of bone. Eriksson AR et al (1984)[37] showed that local bone necrosis would occur in cases where the temperature exceeds 47°C for 1 min due to the contact of rotating tools.

In order to minimize these difficulties, piezoelectric bone surgery was introduced by Tomaso Vercelloti[86] in 2000 as an alternative in ridge split procedure. Rahnama M et al (2013)[68] reported that piezoelectric bone surgery seems to be more efficient during the first phases of bone healing. It induces an increase in bone morphogenetic proteins (BMPs), controls the inflammatory process better and stimulates remodeling of bone as early as 56 days after treatment. Vercelloti T et al

(2001)[85] also reported that the piezosurgery made ridge split technique easier, safer and also reduced the risk of complications in treatment of extreme atrophic sites.

There are various modern devices which are reported to perform a ridge split include threaded bone expanders, bone expansion device, extension crest device, motorized bone expanders, Er: YAG laser and piezosurgery device.

Shiak LS et al (2016)[74] has done ridge split using mallet and Osteotome kit to attain adequate ridge expansion with fracture of two buccal plates. Kawakami PY et al (2013)[47] reported that ridge expansion can be obtained using surgical burs, saw and chisel and showed an increase in width of 4 mm. Ridge split using bone expansion device was done by Ella B et al (2014)[35] showed that an increase of 3mm in ridge width was obtained with complications like buccal plate fracture in 43% cases.

Sohn DS et al (2010)[76] used Er: YAG laser and piezoelectric saw in reconstruction of atrophic alveolar ridge which resulted in 2-4 mm increase in ridge width with 5 buccal plate bone fracture. A histological study was reported by Esteves JC et al (2013)[38] showed, that new bone formation is slightly higher in piezosurgery treated sites when compared with sites treated with conventional drills.

Various authors like Crespi R et al (2014)[28], Teng F et al (2014)[83], Gonzalez Garcia R et al (2011)[40], and Kawakami PY et al (2013)[47] reported many in vitro and in vivo studies in ridge split with traditional devices like osteotomes, surgical burs, saws and mallets. On the other hand, Ella B et al (2014)[35], Rodriguez JG et al (2013)[71], Mazzocco F et al (2011)[52], Cortes AR et al (2010)[27], Danza M et al (2009)[30] performed ridge split using modern devices such as threaded bone expanders, motorized bone expanders and piezosurgery device.

In the present study, a total of 10 sites among 5 patients with bilateral edentulous sites in posterior atrophic mandible were selected. One quadrant on each side was randomized to the two treatment sites into either test and control sites. In the control sites ridge split and implant site preparation was done using rotary instruments and in test sites ridge split and implant site preparation was done using piezo electric device.

After initial examination, presurgical bucco-lingual width of the edentulous sites was verified by Cone Beam Computed Tomography (CBCT) and Orthopantamogram (OPG). During surgery under local anesthesia, full thickness flap was raised and the bucco-lingual dimension of the ridge was directly measured with Castroviejo caliper. In control site Corticotomy cuts were given by using tapered fissure carbide bur (701) and implant site preparation was performed with rotary drills. In test sites Corticotomy cuts were given by using piezoelectric device with surgical tip OT7 (NSK®) and implant site preparation was performed with specific piezo electric inserts SG15A, SG15B, SG16A, and SG16B (NSK®). Implants with same diameter and length were placed on both control and test sites.

Immediately after implant placement, the ridge width was measured using Castroviejo caliper followed that the stability of implant was assessed using universal hand torque wrench and by using Osstell® device. Bone graft and membrane were placed in the surgical site and flaps were approximated with sutures. Suture removal was done after 7 days. All patients were followed for 1 week post-operatively then on intervals of 1 and 3 months respectively. Soft tissue healing of the surgical site was monitored on regular intervals. Implant stability, bucco-lingual width of the ridge and bone loss around implants were assessed at the end of 3 month after implant placement.

Most reported studies and case reports used either a traditional or modern device but to the best of our knowledge there were very few studies comparing both the devices. In this present study we compared the traditional rotary instruments with modern piezo bone surgical device in ridge expansion and implant site preparation.

While many studies have shown positive results in single stage split ridge technique, Elian N et al (2008)[34] and Enislidis G et al (2006)[36] reported that two stage approaches is preferable to simultaneous ridge expansion with implant placement. But Demetriades N et al (2011)[32] reported that there were no difference between immediate and late implant placement and they established that split crest bone augmentation is a valid procedure used to augment the horizontal alveolar defect. In this present study we used single stage ridge split technique for reconstruction of deficient posterior mandibular edentulous sites.

Study performed by Ramal A et al (2018)[69] showed 2.29 mm mean gain in bucco-lingual width of the ridge is in well accordance with the current study which resulted in 2.8 mm mean gain in clinical bucco-lingual width of the ridge after ridge expansion using piezosurgery. Study conducted by Holtzclaw DJ et al (2010)[44] also showed parallel results as obtained with the present study.

While comparing the CBCT and surgical caliper measurement of bucco-lingual ridge width, the mean change of radiographic and clinical measurements of the bucco-lingual width after 3 months among test and control sites was highly statistically significant. This study correlates well with the study done by Agabiti I et al (2017)[2], where in the mean initial width of the alveolar bone crest measured 4.1±0.5mm, reaching 6.8mm± 0.9mm after ridge expansion.

Here in this study both the piezoelectric surgical device and rotary instruments were used for expansion of ridge, at the end of the study there was increase in bucco-lingual width of the ridge in both the techniques but comparatively higher in piezosurgery treated sites. This increase in width correlates well with other published studies.

Implant stability plays a significant role in success of implants. Stability of implants depends upon the quality of bone, surgical technique, type of implants and surgeon's skill and knowledge. Various techniques are used to assess the stability of implants. The most reliable and latest method of assessing implant stability is Resonance Frequency Analysis (RFA). In this study, implant stability was assessed immediately after implant placement by torque wrench and Resonance Frequency Analysis (RFA) and at the end of the study (after 3 months) using Resonance Frequency Analysis (RFA). There was a positive correlation between the values obtained by torque wrench and ISQ obtained in this study.

The ISQ values usually at the time of surgery can be seen as a low numerical value. This is expected since the implants placed immediately after the ridge split procedure may have lower primary stability due to bone contact originated from apical aspect of the osteotomy site. It was also found that there was an increase in the ISQ values of all implants during the osseointegration period.

The mean change in the ISQ values of implants immediately after their placement and after 3 months was 9.7 in the test sites and 5.1 in the control sites respectively. Results shows there was no statistical significant between test and control sites which is in contrast with the study reported by da Silva Neto UT et al (2014)[29] which was performed on 30 patients with 150 days follow up, wherein the

results comparing ISQ values between the piezo and the rotary sites were statistically significant. In our study we couldn't attain statistical significant results may be due to small sample size and short term follow up.

Even though there was no statistical significance between test and control sites, there was an increase in ISQ values in both sites. But comparatively ISQ values were higher in piezo treated sites than control sites.

Another factor that can influence ISQ values is the amount of marginal bone loss around the implant. According to Albrektsson T et al (1993)[6] the evaluation of vertical and horizontal bone change surrounding the implant is an important measure of implant success. Marginal bone loss is directly associated with the long term success of implant treatments (Rasouli Ghahroudi AAR 2014)[70].The level of crestal bone is usually a significant indicator of implant health, for its success and longevity. The radiographic evaluation of marginal bone forms an important and viable means of assessing health and stability of bone around implants.

First few months immediately after implant placement are considered as an active phase of bone loss, which was not extensively studied. Adell R et al (1981)[1] reported that this rapid initial bone loss might be due to the surgical trauma, elevation of periosteum or by stress concentration from extensive tightening of the implant. Hence, in our study, radiographic assessment of marginal bone dimension around implants placed by ridge split has been done immediately after implant placement and after 3 months.

In this study, in test sites amount of radiographic bone loss increased from 1.04 mm to 2.06 mm after 3 months in mesial sites and from 1.04 mm to 1.9 mm in distal sites respectively. In control sites amount of radiographic bone loss increased

from 0.5 mm to 1.5 mm in mesial sites and 0.37mm to 1.4 mm in distal sites respectively. The mean values of recorded bone loss around mesial and distal aspects of implants immediately after their placement and after 3 months among test and control sites was not statistically significant which is similar to the studies reported by Bruschi GB (2017)[17] and Nandal S (2014)[60].

Within the limitations of the present study, the piezo treated sites showed better soft tissue healing, while compared with the rotary treated sites which may be due to the selective cutting action of the piezosurgical device. It minimizes the soft tissue damage by absence of macro vibrations and by providing better control.

The main surgical risk of the ridge split procedure is the fracture of the labial cortical plate. Sohn DS et al (2010)[76], Shiak LS et al (2016)[74] also reported fracture of buccal plates during ridge split procedure. In this study during the surgical procedure, minor fracture of buccal plate occurred in 1 of the 10 sites and in the fractured site decortication of buccal plate was done; bone graft was placed on the fracture line and covered with resorbable collagen membrane, which healed uneventfully.

Another complication we encountered during osteotomy by rotary bur, the head of the bur got fractured, which was retrieved immediately and the procedure was successfully completed by using another new bur. This complication could have been due to the increased pressure given by the operator, angulation of the bur and also due to narrow shank of the long bur which may cause fracture of the bur. This can be easily avoided by using piezo tips and make the procedure simple and efficient without any of these complications.

There was on exposure of cover screw in 2 of the 10 sites during the first month of post-operative period. For those patients who have cover screw exposure,

the site was irrigated with 0.12% chlorhexidine and efficient home care instructions were given for cleansing the exposed area. These complications could have induced the early marginal bone loss seen around these implants.

Studies reported by Stacchi C et al (2011)[78] and da Silva Neto UT et al (2014)[29] on piezoelectric and rotary implant site preparation claimed that high implant stability(ISQ) can be obtained with the use of piezo surgical device. Within the limitations of the present study, the piezo treated sites showed higher ISQ values while compared to rotary instrument treated sites which was not statistically significant. This may occurred due to short term follow up and small sample size.

Ridge split procedure excludes the need for onlay grafts which have to be harvested from intra oral and extra oral sites. It also avoids the use of secondary surgical site; thereby it reduces the post-operative morbidity associated with other ridge augmentation techniques. Ridge split procedure along with immediate implant placement shortens the treatment time and is also cost effective. To utilize the advantages of these, ridge split technique was done to rehabilitate the posterior atrophic ridges with horizontal deficiency.

The piezoelectric bone surgery is a safe, precise, bone cutting system based on ultrasonic micro vibrations and spares soft tissue. Vercellotti T et al (2005)[87] and Preti G et al (2007)[66] reported that an ultrasonic cut induces an earlier increase in bone morphogenetic proteins (BMP)-4 and transforming growth factor (TGF)-β2 levels which controls the inflammatory process and stimulates faster bone remodeling. By using piezosurgery device in ridge split procedure, the horizontal and vertical bone incisions can be easily performed without any complications. This technique favors expansion of ridge which creates adequate osseous support for implants with minimal

post-operative morbidity. Based on the results of our study, the piezoelectric device can be considered to be more effective, compared with traditional rotary instruments in providing more implant stability and maintaining osseous support around implants.

Further clinical and histological studies are required with large sample size and long-term follow up to evaluate the efficiency of piezoelectric device and to understand the healing and formation of bone around implants after piezoelectric bone surgery.

Summary & conclusion

The present study was done to evaluate the changes in implant stability, bucco-lingual width of the alveolar ridge and marginal bone level that occurs after ridge split procedure with implant placement using piezoelectric bone surgery and rotary instruments. In this study, piezoelectric bone surgery was combined with traditional rotary instruments in rehabilitation of bilateral edentulous posterior atrophic mandible.

A total of ten sites among five patients were selected and randomly divided into control and test site. Control sites were treated with piezoelectric device and test sites were treated with rotary instruments. All the patients were periodically examined after 7 days, 1 month and 3 months post-operatively.

The amount of gain in implant stability, bucco-lingual width of the ridge and changes in marginal bone level obtained in this study correlated well with other studies.

Based on this study, it can be concluded that,

- Piezoelectric device is a safe, less sensitive and an efficient bone cutting device without risk of soft tissue trauma which can be used for ridge splitting and implant site preparation.
- There was an increase in ISQ values obtained in piezo treated sites while compared with rotary treated sites. The amount of implant stability obtained improved the survival rate of implants and met with the expectations and demands of the patients and also the treating surgeon.
- There was an increase in bucco-lingual width in 3 months in the sites treated with piezo electric device which was statistically significant.

The results obtained from this study confirm the efficiency of piezoelectric device in implant site osteotomies. Within the limitations of the study, the results should be interpreted with due consideration given to the following.

- Relatively small sample size (n=10)
- Short follow-up period

However, longer follow-up studies have to be conducted with large sample size to know to explore about the influence of piezosurgery in hard and soft tissues. Furthermore histological studies are also needed to analyse the mechanism of bone formation over time, using piezoelectric device.

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Annexures

The Diocese of Madurai - Ramnad
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ETHICAL COMMITTEE

Title of the work : Rehabilitation of narrow ridge with ridge split using piezotome versus rotary along with bone graft – A clinical comparative study

Principal investigator : Dr.G.Abirami, II MDS

Department: Periodontology **CSICDSR/IEC/0019/2016**

The request for an approval from the Institutional Ethical Committee (IEC) for the above mentioned study, submitted by the principal investigator is considered on the IEC meeting held on 08.09.2016 at CSI College of Dental Sciences and Research, Madurai. The members of the committee, the president, vice president, and the secretary are pleased to approve the proposed work mentioned above and is **'Advised to proceed with the study'**

The principal investigator and their team are directed to adhere the guidelines given below:

1. You should get detailed informed consent from the patients/participants and maintain confidentiality.
2. You should carry out the work without detrimental to regular activities as well as without extra expenditure to the Institution or Government.
3. You should inform the IEC in case of any change of study procedure, site and investigation or guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s).
6. You should complete the work within the specific period and if any extension of time is required, you should apply for the permission again and do the work.
7. You should submit the summary of the work to the ethical committee on completion of the work.
8. You should not claim funds from the institution while doing the work or on completion.
9. You should understand that the members of IEC have the right to monitor the work with prior intimation.
10. Your work should be carried out under the direct supervision of your Guide/Professor.

Dr.A.Charles MS MCh
President

Dr.N.Gururaj MDS
Secretary

INFORMED CONSENT FORM

The study entitled "REHABILITATION OF NARROW RIDGE WITH RIDGE SPLIT USING PIEZOTOME V/S ROTARY ALONG WITH BONE GRAFT - A CLINICAL COMPARATIVE STUDY" will be undertaken in the DEPARTMENT OF PERIODONTOLOGY, CSI College of Dental Sciences and Research, Madurai for which, I have been explained all the procedures by Dr. G.ABIRAMI. (Investigator).

I have been explained about the procedure regarding the study and I am willing to take part as a subject in this study and cooperate with dental examination. I had the opportunity to ask questions concerned with the study and it has been well explained to me in native language.

With full understanding I, Mr/Miss/Mrs _____

O.P No._____ Age_____ Sex_____ hereby authorize and give my consent to the Investigator concerned.

I agree to the following:

- I have been informed to my satisfaction about the purpose of the study and study procedure including investigations to monitor and safeguard my body function.
- I agree to cooperate fully.
- I agree to inform my doctor immediately if I suffer any unusual symptom.
- I have informed the doctor about all medications I have taken in the recent, past and those I am currently taking.
- I hereby give permission to use my medical records for research purpose. I am told that the investigating doctor and institution will keep my identity confidential.

Signature of investigator Signature of patient/Thumb impression

Date:

Place: Madurai

சி.எஸ்.ஐ பல் மருத்துவக்கல்லூரி மற்றும் ஆராய்ச்சி மையம்
மதுரை

ஈறுநோய் அறுவை சிகிச்சை பிரிவு
ஆராய்ச்சி ஒப்புதல் படிவம்

ஆராய்ச்சியின் தலைப்பு

குறுகிய பல் இல்லாத கீழ்தாடை பகுதியை மீயொலி கருவி (Piezo) மற்றும் சுழறும் கருவி (rotary) மூலம் மறுசீரமைத்து அதன் பலன்களை ஒப்பிடும் ஆய்வு.

பெயர் : _____ வரிசை எண்: _____

வயது / பால் : _____ புறநோயாளி எண்: _____

முகவரி: _____

தொலைபேசி எண் : _____

திரு/திருமதி: _____ ஆகிய நான் மேற்கண்ட ஆராய்ச்சியில் பங்கு பெற முழுமனதோடும் என் சுயநினைவுடனும் சம்மதிக்கிறேன். மேலும் பின்வரும் நிபந்தனைகளுக்கு ஒப்புதல் அளிக்கிறேன்.

எனக்கு இந்த ஆராய்ச்சியின் நோக்கம், ஆராய்ச்சியில் மேற்க் கொள்ளப்படும் சிகிச்சை முறைகள் மற்றும் அதன் பக்கவிளைவுகள் பற்றி பல் மருத்துவர் டாக்டர் கோ.அபிராமி அவர்களால் விரிவாகவும் எளிமையாகவும் தமிழில் எடுத்துரைக்கப்பட்டது. மேலும் அதில் எனக்கு ஏற்பட்ட சந்தேகங்களை கேட்கவும் வாய்ப்பளிக்கப்பட்டது.

நான் பல் மருத்துவரிடம் எனது உடல்நிலை பற்றியும் இதற்கு முன்னர் மற்றும் தற்பொழுது உட்கொள்ளும் மருந்துகள் பற்றியும் முழுமையாக தெரிவிப்பேன்.

மேற்கண்ட ஆராய்ச்சிக்காக புகைப்படம் எடுப்பதற்கும் பற்கள் சம்பந்தப்பட்ட எக்ஸ்ரேக்கள் எடுப்பதற்கும் ஒத்துழைப்பேன். மேலும் என் மருத்துவ படிவங்களை ஆராய்ச்சிக்காக உபயோகப்படுத்தவும் சம்மதிக்கிறேன்.

நான் மருத்துவர் அளிக்கும் அறிவுரைகளை தவறாமல் கடைப்பிடிப்பேன்.

மருத்துவர் கையொப்பம் நோயாளியின் கையொப்பம்

இடம் : _____

தேதி : _____

CSI COLLEGE OF DENTAL SCIENCES AND RESEARCH, MADURAI

DEPARTMENT OF PERIODONTICS AND IMPLANT DENTISTRY

CASE PROFORMA

REHABILITATION OF NARROW RIDGE WITH RIDGE SPLIT USING PIEZOTOME V/S ROTARY ALONG WITH BONE GRAFT - A CLINICAL COMPARATIVE STUDY

NAME: **OP NUMBER:**

AGE /SEX: **DATE:**

OCCUPATION: **INCOME:**

ADDRESS: **PHONE NUMBER:**

CHIEF COMPLAINT:

HISTORY OF PRESENTING ILLNESS:

DETAILED MEDICAL HISTORY:

PAST DENTAL HISTORY:

PERSONAL HISTORY:

HABITS:

ORAL HYGIENE MEASURES:

CLINICAL EXAMINATION:

EXTRAORAL EXAMINATION

A) Facial symmetry:
B) Lymph node examination:
C) Lip seal:
D) TMJ examination:

INTRAORAL EXAMINATION

A) Number of teeth present:
B) Occlusion:
C) Missing teeth:

- Duration:
- Extraction due to:

D) Dental caries:
E) Mobility:
F) Impacted:
G) Root stumps:

GINGIVAL EXAMINATION

GINGIVAL STATUS DESCRIPTION REGION

Color

Contour

Consistency

Fibrous

Edematous

Surface texture

Gingival recession Present/Absent

Class I	Class II	Class III	Class IV

Exudate Present/Absent

If present- Serous/Purulent

Bleeding on probing Present/Absent

BUCCO-LINGUAL WIDTH OF THE ALVEOLAR RIDGE (in mm)

PIEZO SURGERY			ROTARY INSTRUMENT		
TEST SITE	Caliper	CBCT	CONTROL SITE	Caliper	CBCT
PRE OPERATIVE			PRE OPERATIVE		
POST OPERATIVE			POST OPERATIVE		
AFTER 3 MONTHS			AFTER 3 MONTHS		

IMPLANT STABILITY

PIEZOSURGERY (TEST)				ROTARY INSTRUMENT (CONTROL)			
IMPLANT	HAND WRENCH	RESONANCE FREQUENCY ANALYSIS		IMPLANT	HAND WRENCH	RESONANCE FREQUENCY ANALYSIS	
	Immediately after implant placement	Immediately after implant placement	After 3 months		Immediately after implant placement	Immediately after implant placement	After 3 months

RADIOGRAPHIC CRESTAL BONELOSS AROUND DENTAL IMPLANTS (in mm)

PIEZOSURGERY (TEST)			ROTARY INSTRUMENT (CONTROL)		
IMPLANT SITE	BASE LINE	AFTER 3 MONTHS	IMPLANT SITE	BASE LINE	AFTER 3 MONTHS

SOFT TISSUE HEALING ASSESSMENT (Healing index-Landry t al 1988)

	After 24 hrs	7^{th} day	After 1 month
TISSUE COLOR			
BLEEDING ON PALPATION			
GRANULATION TISSUE			
INCISION MARGIN			
SUPPURATION			

INVESTIGATIONS

- ROUTINE BLOOD INVESTIGATION
- OPG
- CBCT

DIAGNOSIS

TREATMENT PLAN

DATE **STAFF SIGNATURE**

URKUND

Urkund Analysis Result

Analysed Document:	whole thesis.docx (D45865833)
Submitted:	12/17/2018 10:51:00 AM
Submitted By:	dr.abivel@gmail.com
Significance:	10 %