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Research Article

Piezosurgery: A Minimally Invasive Modern Technique for Alveoloplasty

[1]Dr. Sonal Madan, [2]Dr. Deval Mehta, [3]Dr. Aartiben Mali, [4]Dr. Heema Bajaria*

[1]Professor, Dept. of OMFS, College of dental science and research center, Ahmedabad, Gujarat, India.
[2]Dean, HOD, Dept. of OMFS, College of dental science and research center, Ahmedabad, Gujarat, India.
[3]Consultant Oral and Maxillofacial surgeon, Ahmedabad, Gujarat, India.
[4]Post Graduate Resident & corresponding author, Dept. of OMFS, College of dental science and research center, Ahmedabad, Gujarat, India.

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Corresponding author: Dr. Heema Bajaria
Post Graduate Resident & corresponding author, Dept. of OMFS, College of dental science and research center, Ahmedabad, Gujarat, India.

Abstract

***Background**: Edentulism is the condition of being toothless. [1] A well-contoured smooth alveolar ridge is crucial for appropriate fabrication of denture. [2] Alveoloplasty is one of the common pre prosthetic surgeries done.[3] Bone cutting can be performed with either manual or powered instruments [4] Piezosurgery is a promising system for bone cutting, based on ultrasonic microvibrations.[5] This study aims at evaluating the efficacy of alveoloplasty done with piezosurgery system compared with that of the conventional technique.*

***Material and methods**: This study was an experimental, randomized, split mouth clinical trial, conducted on a total 32 sites from 13 patients. Patients were followed up for regular intervals up to the 3 months.*

***Results**: The piezo unit took longer time duration to complete surgery than conventional method. Pain, swelling, healing was evaluated on 2nd, 7th and 15th post-operative days showing significantly higher pain on 2nd and 7th post-operative day in conventional group and a higher swelling on 2nd and 7th post operative day compared to 15th post operative day in conventional group. Good healing score on 2nd and 7th post operative day with piezo group but result was not significant on 15th post operative day suggestive of faster healing with piezo unit. Bone resorption score was highly significant on 3rd month indicating higher bone resorption in conventional group.*

***Conclusion**: Piezoelectric devices are an innovative ultrasonic technique for safe and effective osteotomy or osteoplasty because of the absence of macrovibrations, ease of use and control, and safer cutting, particularly in complex anatomical areas.*

***Keywords:** Edentulism, Piezoelectric, Alveoloplasty, Preprosthetic.*

I. INTRODUCTION

Edentulism may lead to a condition called oral dyskinesia, which is defined as abnormal, involuntary, shaped or standardized and aimless oro-facial movements. It can occur due to several factors such as ill-fitting dentures and unstable prostheses, oral discomfort etc.[1] A well-contoured smooth alveolar ridge is crucial for appropriate fabrication of complete or partial denture.[2] Ill-fitting dentures and unstable prosthesis can be the outcome of not performing the pre prosthetic surgeries. [1] The aim of preprosthetic surgery is to improve the quality and condition of the hard and soft oral supporting structures, so that they can provide better retention, support and stability to the dental prosthesis. Alveoloplasty is one of the common pre prosthetic surgeries done in dental practice. The objective of alveoloplasty is to round off sharp bony edges and to remove any gross bony irregularities and undercuts present after the extractions.[3] Based on the clinical scenario alveoplasty can be performed as a primarily at the time of extraction or secondarily that is carried out after the post extraction healing to eliminate the gross bony irregularities.

Bone cutting can be performed with different instruments, either manual (bone chisels, rongeurs) or powered (rotary burs, oscillating saws). Manual bone cutting instruments require use of high forces, which may lead to uncontrolled damage to the bone or to the surrounding structures. However, in powered method thermal injury to the tissues, entrapment o surrounding soft tissues during osteotomy resulting in severe damage to muscles, nerves, and blood vessels especially at sites with difficult or limited accesses. [4]

Piezosurgery (piezoelectric bone surgery) is a promising, meticulous and soft tissue sparing system for bone cutting, based on ultrasonic microvibrations. It was developed by Italian oral surgeon Tomaso Vercellotti in 1988 to overcome the limits of traditional instrumentation in oral bone surgery.[5] The technology is based on inverse piezoelectric activity: Alternative current applied to piezo active ceramic disks generates high-frequency vibratory energy. Frequencies of 25–35 kHz (Hertz=vibrations/s) are specific for cutting mineralized tissue, where as soft tissue incisions require frequencies above 50kHz. [4]

II. MATERIALS AND METHODS:

A prospective study was designed to evaluate the efficacy of alveoplasty done with piezosurgery system compared with that of the conventional technique on a soft tissue and bone healing. This study was implemented as a split mouth in vivo study, conducted on a total 32 sites from 13 patients after clearance from the ethical committee on the population reporting to the OPD of Department of Oral and Maxillofacial Surgery from 2020-2023. The procedure was carried out either in maxilla or mandible by dividing into quadrants. Each quadrant was considered as individual experimental site for ease of evaluation.

INCLUSION CRITERIA:

1. Class 2 Post Extraction Ridge (Cawood and Howel's Classification) [6],
2. Bony irregularities present bilaterally on edentulous alveolar ridge,
3. Patients willing for follow ups,
4. Medically healthy patients.

EXCLUSION CRITERIA:

1. Patients with bleeding disorders,
2. Patient with bone diseases affecting bone healing,
3. Uncontrolled systemic comorbidities,
4. Unilateral bony irregularities.

SELECTION OF PARAMETERS

CLINICAL:

- Intra operative parameters

1. Time

- Post operative parameters

1. Swelling (Gabka and Matsumara technique)
2. Early Wound Healing score (EHS). (Marini et al. 2018)
3. Pain (Visual Analogue Scale). (Hayes and Patterson 1921)

RADIOGRAPHIC:

1. Pre op, immediate post op and 3 months post op: CBCT (to evaluate bone resorption)

ARMAMENTARIUM (Figure 1):

1. Local anesthesia (2% lignocaine with 1:80,000 adrenaline),
2. Mouth mirror, probe and tweezer,
3. Suction tip,
4. Towel clips,
5. Retractors,
6. Normal saline,
7. Gauze pieces,
8. Surgical drape and trolley cover,
9. Gloves,
10. Bard parker (BP) handle,
11. 15 number BP blade,
12. No. 9 Molt periosteal elevator,
13. Bone rongeur,
14. Bone file,

15. Straight handpiece,
16. Bone trimming bur,
17. Piezo unit,
18. Piezo inserts,
19. Needle holder,
20. Toothed forcep,
21. 3-0 silk suture material,
22. Suture cutting scissor,
23. Tissue cutting scissor

FIGURE 1: ARMAMENTARIUM FOR ALVEOLOPLASTY

a) ARMAMENTARIUM FOR PIEZO SURGICAL ALVEOPLASTY

b) ARMAMENTARIUM FOR ALVEOPLASTY

c) ARMAMENTARIUM FOR CONVENTIONAL ALVEOPLASTY

METHODOLOGY:

A detailed history was recorded and patient was clinically examined to reach diagnosis. Routine haematological investigations were carried out. Pre operative CBCT was taken.

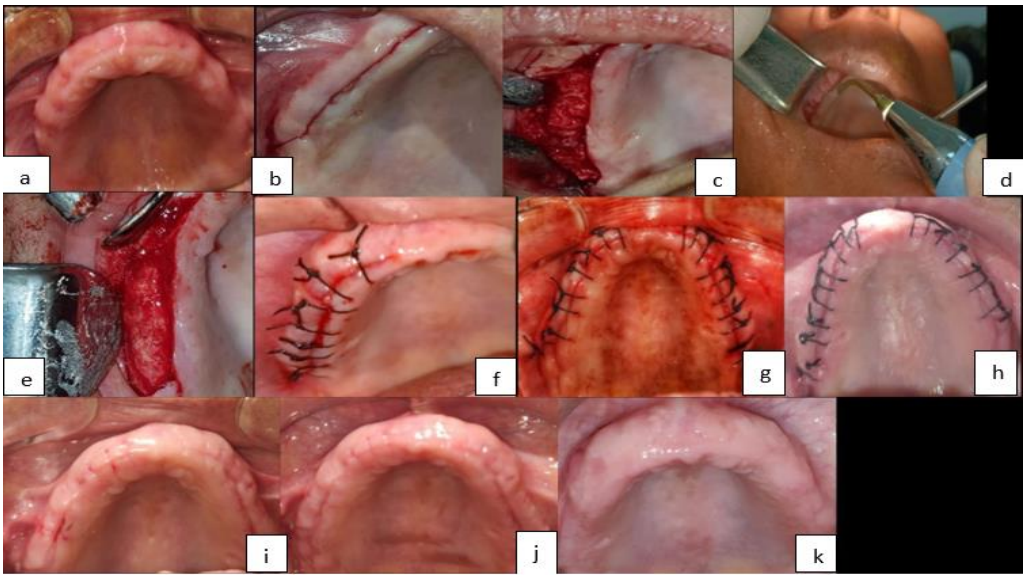
Conventional and piezo sides were selected based on the random method.

Group 1 – Piezo electrically operated site
Group 2 – Conventionally operated site

In the study group side, alveoplasty was performed with piezoelectric tip US4, US5, UL4 in the piezotome (Figure 2). In the opposite side, alveoloplasty was performed using bone rongeur, bone file, bone trimming bur connected with micro motor rotating at 35,000 rpm (Figure 4). Procedure was performed under local anaesthesia. In both sides depending upon the exposure needed crestal with vertical releasing incision was placed with no 15 blades. Full thickness mucoperiosteal flap was reflected using No. 9 Molt periosteal elevator. Flap was reapproximated using 3-0 non absorbable silk suture material with interrupted sutures to attained primary healing. Intra operative time for alveoplasty was noted using stop watch. Both the surgical procedures; conventional alveoplasty and alveoplasty using piezo surgery were performed in the same surgical session by same surgeon. Radiographic evaluation included pre op CBCT to interpretate bony irregularity was present, immediate post op CBCT to interpretate the bone reduction performed by surgeon and after 3 months CBCT to interpretate the amount of bone resorption occurs by comparing it with previous radiograph. Patients were recalled for follow up on 2^{nd}, 7^{th} 15^{th} post operative day and 3^{rd} month post operatively; intraoral and extraoral photographs were

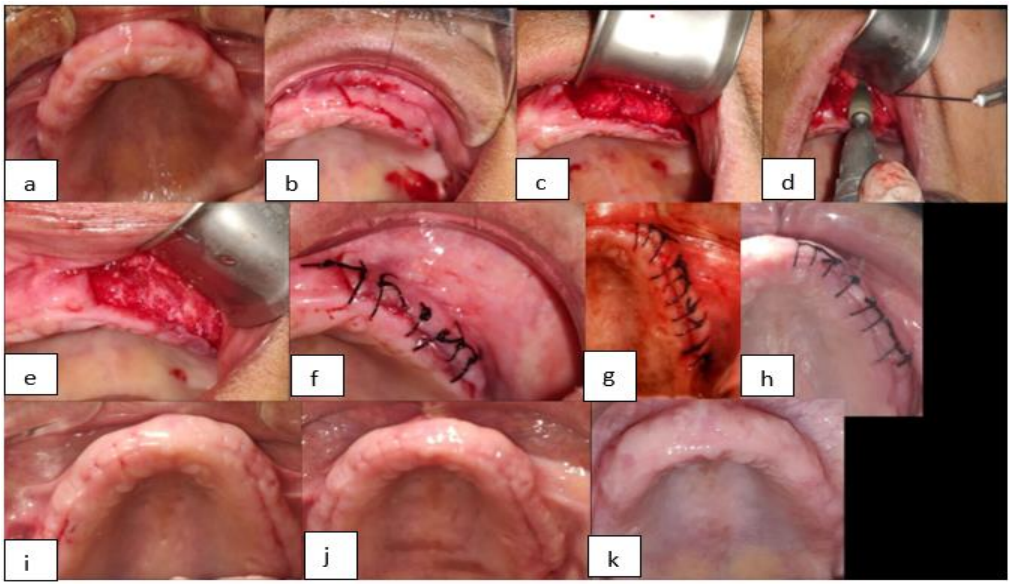
taken, clinical evaluation and radiographic evaluation were performed. On 7th day after evaluating healing suture removal was performed.

FIGURE 2: STUDY GROUP CASE – ALVEOPLASTY DONE WITH PIEZOELECTRIC UNIT



a) PREOP INTRAORAL IMAGE
b) TRIANGULAR INCISION DESIGN
c) FLAP REFLECTION
d) ALVEOLOPLASTY USING PIEZOELECTRIC UNIT
e) ALVEOPLASTY COMPLETED
f) PRIMARY CLOSURE OF FLAP
g) TISSUE HEALING ON 2ND DAY
h) TISSUE HEALING ON 7TH DAY
i) AFTER SUTURE REMOVAL
j) TISSUE HEALING ON 15TH DAY
k) TISSUE HEALING AT 3RD MONTH

FIGURE 4: CONTROL GROUP CASE– ALVEOPLASTY DONE WITH CONVENTIONAL METHOD



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III. RESULTS:

The statistical analysis was performed in SPSS version 23.0. Intra group comparison was done using Student 't' test Unpaired and for inter group comparison Student 't' test Paired, Mann-Whitney Test, Wilcoxon-Signed Rank Test were used.

Intra operative duration of procedure of each site was noted in terms of seconds only for the procedure of bony contouring. The mean value of time duration intra operatively was longer in Group 1(mean value - 722.188) than Group 2(mean value - 423.00) with Highly Significant p value - 0.0003.

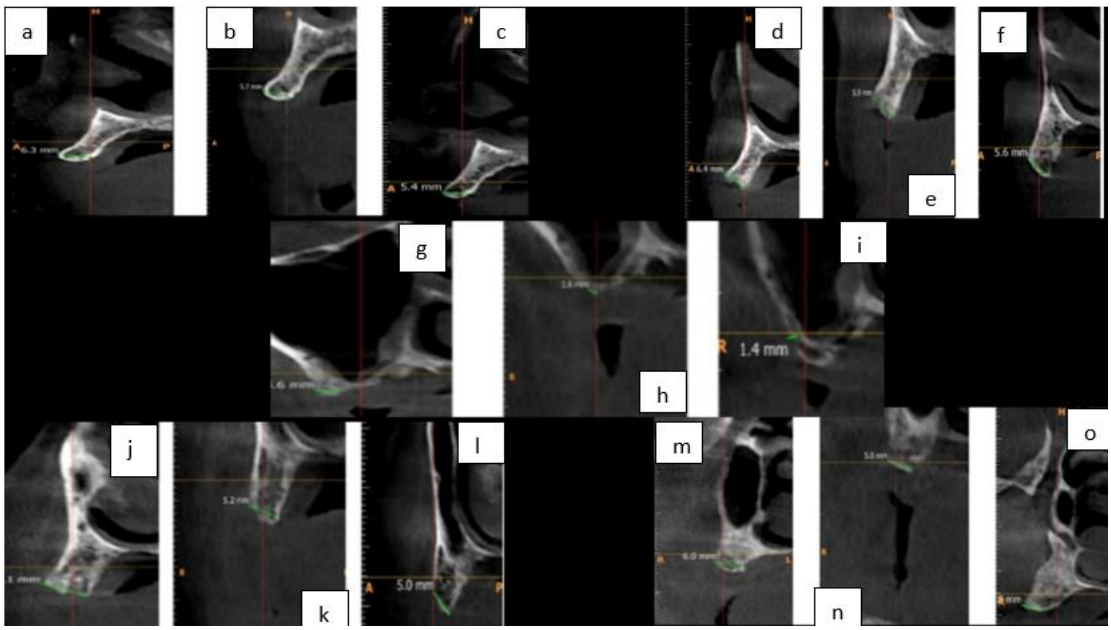
The mean value of VAS score for pain in Group 1 on 2nd post operative day was 2.38, on 7th post operative day was 0.81, on 15th post operative day was 0.06. Whereas in Group-2, the mean value of VAS score on 2nd post operative day was 3.75, on 7th post operative day was 2.00, on 15th post operative day was 0.31. Group-2 showed significantly higher amount of VAS scores 2nd post operative day (p value-0.0415), 7th post operative day (p value-0.0253) and not significant scores on 15th post operative day (p value-0.0746) than patients of Group-2.

Inter group comparison of swelling; On the 2nd post operative day, the mean swelling score of Group 1 and 2 was 12.051mm and 12.954 mm, respectively. On 7th post operative day, group 1 had 11.749 mm and group 2 had 12.188 mm score and on the 15th post operative day, group 1 had 11.581 mm and group 2 had 11.663 mm score. These findings were suggesting that there was a substantial difference in swelling on 2nd and 7th post operative day as compared to 15th post operative day.

Inter group comparison; the mean EHS score in Group-1 on 2nd post operative day was 5.94, on 7th post operative day was 8.88 and on 15th post operative day was 9.44. Whereas in Group-2 the mean post-operative EHS score on 2nd post operative day was 3.88, on 7th post operative day was 7.13 and on 15th post operative day was 9.75 indicating that group 1 showed significantly higher healing score on 2nd post operative day (p value-0.0121) and on 7th post operative day (p value- 0.0323) but result was not significant on 15th post operative day (p value- 0.5264).

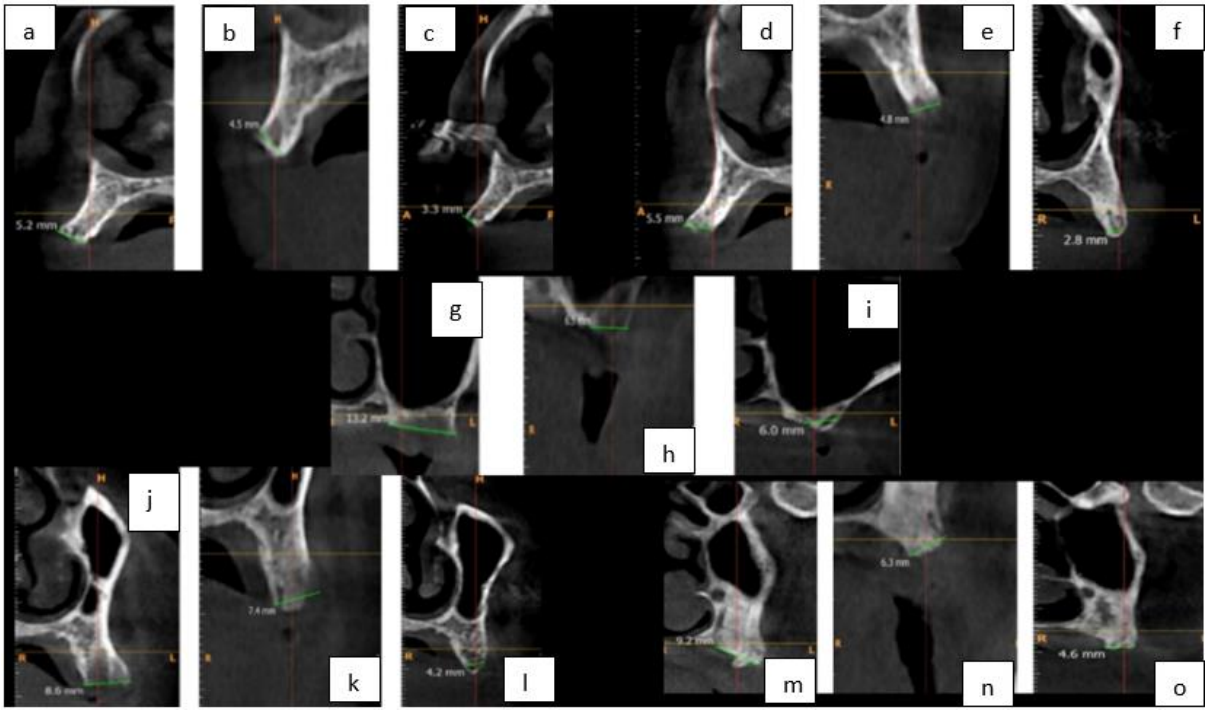
For bone resorption score: Group-1 pre operatively mean value of present bone was 7.591, immediate post operatively was 6.458 and on 3rd month was 5.909 (Figure 3). Whereas in Group-2 pre operatively was 7.446, immediate post operatively was 6.142 and on 3rd month was 4.584 (Figure 5) indicating that result was not significant pre operatively (p value-0.8269) and immediate post operatively (p value- 0.5760) but result was highly significant on 3rd month (p value-0.0111) indicating that higher bone resorption was noted in group 2 than group 1.

FIGURE 3: STUDY GROUP CASE – ALVEOPLASTY DONE WITH PIEZOELECTRIC UNIT



a) CBCT - CENTER OF NASAL CAVITY REGION - PREOPERATIVE
b) CBCT - CENTER OF NASAL CAVITY REGION - IMMEDIATE POSTOP
c) CBCT - CENTER OF NASAL CAVITY REGION - 3RD MONTH POSTOP
d) CBCT - LATERAL BORDER OF NASAL CAVITY - PREOPERATIVE
e) CBCT - LATERAL BORDER OF NASAL CAVITY - IMMEDIATE POSTOP
f) CBCT - LATERAL BORDER OF NASAL CAVITY - 3RD MONTH POSTOP
g) CBCT - MEDIAL BORDER OF MAXILLARY SINUS - PREOPERATIVE
h) CBCT - MEDIAL BORDER OF MAXILLARY SINUS - IMMEDIATE POSTOP
i) CBCT - MEDIAL BORDER OF MAXILLARY SINUS - 3RD MONTH POSTOP
j) CBCT - CENTER OF MAXILLARY SINUS - PREOPERATIVE
k) CBCT - CENTER OF MAXILLARY SINUS - IMMEDIATE POSTOP
l) CBCT - CENTER OF MAXILLARY SINUS - 3RD MONTH POSTOP
m) CBCT - LATERAL BORDER OF MAXILLARY SINUS - PREOPERATIVE
n) CBCT - LATERAL BORDER OF MAXILLARY SINUS - IMMEDIATE POSTOP
o) CBCT - LATERAL BORDER OF MAXILLARY SINUS - 3RD MONTH POSTOP

FIGURE 5: CONTROL GROUP CASE– ALVEOPLASTY DONE WITH CONVENTIONAL METHOD



a) CBCT - CENTER OF NASAL CAVITY REGION - PREOPERATIVE
b) CBCT - CENTER OF NASAL CAVITY REGION - IMMEDIATE POSTOP
c) CBCT - CENTER OF NASAL CAVITY REGION - 3RD MONTH POSTOP
d) CBCT - LATERAL BORDER OF NASAL CAVITY - PREOPERATIVE
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f) CBCT - LATERAL BORDER OF NASAL CAVITY - 3RD MONTH POSTOP
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i) CBCT - MEDIAL BORDER OF MAXILLARY SINUS - 3RD MONTH POSTOP
j) CBCT - CENTER OF MAXILLARY SINUS - PREOPERATIVE
k) CBCT - CENTER OF MAXILLARY SINUS - IMMEDIATE POSTOP
l) CBCT - CENTER OF MAXILLARY SINUS - 3RD MONTH POSTOP
m) CBCT - LATERAL BORDER OF MAXILLARY SINUS - PREOPERATIVE
n) CBCT - LATERAL BORDER OF MAXILLARY SINUS - IMMEDIATE POSTOP
o) CBCT - LATERAL BORDER OF MAXILLARY SINUS - 3RD MONTH POSTOP

IV. DISCUSSION:

Alveolectomy has been defined by Boucher in 1974 as “removal of a part of the alveolus by surgery.” In recent years, the term “Alveoloplasty” has been adopted to signify recontouring of the alveolar process rather than its removal.[2]

Alveoloplasty is one of the common pre-prosthetic surgeries done in dental practice. The ultimate aim of Preprosthetic surgery is to improve the quality and condition of the hard and soft oral supporting structures, so that they can provide better retention, support and stability to the dental prosthesis.[3]

Alveoloplasty, a technique used for reshaping the jawbone, has been performed for over a century using a rounger and bone file. While this method is well-established and easy to handle, it has drawbacks such as inadequate or excessive bone cutting and prolonged surgery time. Alternatively, rotary cutting instruments are faster and more effective at removing bone, but they can be harmful as they generate high temperatures that can cause bone damage and hinder healing. [7]

Piezosurgery (piezoelectric bone surgery) is a promising, meticulous and soft tissue sparing system for bone cutting, based on ultrasonic microvibrations.[5] The term "piezo" comes from the Greek word "Piezien," meaning pressure. The piezoelectric effect was first explained by Jacques and Pierre Curie in 1880. While ultrasonic microvibrations technology had been tested earlier, it was in 1988 that Italian oral surgeon Tomaso Vercellotti created the first commercially available Mectron® piezoelectric bone surgery unit, which allowed for more precise bone cutting compared to traditional tools. [8]

The piezoelectric unit also allows for election of modes of operation, which are preset power modes with varying frequencies to match the clinical application The frequency is usually set between 25 and 29 kHz, providing the handpiece with power exceeding 5W. Unit has 3 modes: “Low mode” to perform endodontic procedures, “High mode” to perform periodontal procedures and “Boosted mode” that is most efficient for osteotomy and osteoplasties in surgical procedures. The device includes an irrigating system for cooling that creates an adjustable jet of coolant solution through a peristaltic pump at rates between 0 and 60 ml/min along with LED light. [8]

Piezo system operates based on 3 mechanisms of actions:

1. Selective cutting: The linear vibrations of the tips range between 60 and 200 micro meters horizontally and a 20-60 micro meter in a vertical motion, targeted to cut only mineralized tissue without damaging adjacent soft tissues. Frequency above 50khz is only capable of cutting neurovascular tissues and other soft tissues.[9]
2. Micrometric cutting: For maximum surgical precision and intra operative sensitivity.
3. Cavitation effect: Cavitation is the micro boiling phenomenon occurring in liquids on any solid liquid interface vibrating to an intermediate frequency, corresponding to a rupture of the molecular cohesion in liquids and the appearance of zones of depression that fill up with vapor until they form bubbles that are about to implode.

The Piezo delivers a precise micrometric cut involving the minimum surface area. Thus, offering more time duration for surgery with this action.[10]

A study by Goyal et al (2012) found that using a Piezo surgical unit for removing third molars took significantly longer time compared to using a handpiece. [11] Deepa et al (2016) also mentioned that cutting dense bone with ultrasound can take up to four times longer than using a rotary bur. [12] Beziat et al (2007) concluded that the overall operative time increased when using a piezo unit in craniofacial surgical procedures. [13]

The reason which can explain the reduced post op pain in the piezosurgery groups was ultrasonic vibrations that permit selective and defined cuts, leading to an advanced level of accuracy and safety and less tissue harm than using traditional rotatory burs.[14]

Clinical implantology study by Maglione et al (2019) the analysis carried out on 65 patients; the differences in the frequency of intake of painkillers between the groups over time showed statistically significant difference similar to our study.

The reason for opting pre op and post op CBCT was to compare the bone resorption following the use to rotary cutting and piezosurgery. Since, in any type of osseous surgery, the effects of mechanical instruments on the structure of bone and the viability of cells are important. Histological findings showed less thermal necrosis by piezoelectric bone surgery, thus increasing the presence of live osteocytes.[15] The reason being piezosurgery inserts do not generate pressure and vibrations in the bone when it is being prepared compared to rotary instruments.[16] Additionally, histomorphological studies reveal that piezoelectric surgery increases the concentration of Bone Morphogenic Protein (BMP-4), TGF beta -2, Tumor Necrosis Factor and Interleukin 1, 10 and decreases some of the proinflammatory cytokines in the bone.[17]

V. CONCLUSION:

Piezoelectric devices are an innovative ultrasonic technique for safe and effective osteotomy or osteoplasty compared with traditional methods owing to the reasons that the piezoelectric surgery protects soft tissues, gives better visualization of the surgical field due to high luminosity LED lights and sterile irrigation, reduction of noise and vibration, reduction in stress and fear of the patient, reduction of bleeding. Additionally, it offers better quality of life for patients post surgically by improving soft tissue healing, reducing pain and also improves bone healing in terms of quality and quantity. The

main reported disadvantage of Piezosurgery concerns the increased operating time as a result of the slow rate of cutting. Besides that, expense of piezo unit and the risk of breakage of the surgical tips are also drawbacks.

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STATEMENTS AND DECLARATIONS

- No funds, grants, or other support was received.
- The authors have no financial or proprietary interests in any material discussed in this article.
- This study was performed in line with the Nuremberg code of ethics. Approval was granted by the Ethics Committee of our institute.
- Informed consent was obtained from all individual participants included in the study
- Consent for participation was obtained from all the participants.
- Clinical trial number: Not applicable.

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