A Modified Split-Crest Technique using Piezoelectric Surgery and Immediate Implant Placement in the Atrophic Maxilla

Amr Zahran, BDS, MDS, PhD[1] • Basma Mostafa, BDS, MDS, PhD[2]
Ahmed Hanafy, BDS, MDS[3] • Mona Darhous, BDS, MDS, PhD[4]

Abstract

Background: The successful placement of dental implants is limited by the presence of a deficient maxillary alveolar ridge. This study reports a modified approach to the split-crest technique using piezoelectric surgery in combination with immediate implant placement in management of atrophic maxillary ridges.

Methods: The first author has developed an approach within which expansion of the alveolar ridge and implant placement are combined into a single procedure. A limited number of instruments were required and implants were positioned into predetermined osteotomy sites within the split channel. This placement was utilized to expand the bone during seating. 28 patients were treated by this modified split-crest technique and in total received 56 tapered self-tapping implants.

Results achieved showed a significant increase in the mean maxillary ridge width by 2.93 ± 0.13 mm. The survival rate of the implants was 100%. Implant stability was measured using the Periotest M and ranged between -2.3 and -5.3 at 6 months postoperatively.

Conclusion: This study showed that the modified approach to split -crest technique as presented, is a successful technique for augmenting narrow maxillary ridges and implant placement.

KEY WORDS: Dental implants, split ridge, maxilla, implant survival

1. Professor, Department of Periodontology, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt.

2. Assistant Professor, Department of Surgery and Oral Medicine, National Research Centre, Cairo, Egypt.

3. Assistant Lecturer, Department of Periodontology, Faculty of Dentistry, Beni-Suef University, Egypt.

4. Professor and Chairman of the Department of Periodontology, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt.

INTRODUCTION

The success of dental implant placement predominantly depends on the presence of adequate bone quantity and quality for the edentulous site. Optimal osseous volume bears a positive influence on osseointegration, long term stability and the final esthetic and prosthetic outcomes of the dental implant.[1,2] A deficient alveolar ridge is a major limiting factor in achieving a successful outcome for implant placement. For extreme cases of ridge width deficiency, it would be necessary to prepare the ridge through augmentation procedures[3]. Established bone augmentation techniques for consideration are: distraction osteogenesis, guided bone regeneration, onlay grafting, inter-positional grafting, ridge splitting or expansion, sinus augmentation and in some cases ridge shortening.[4,5] Ridge splitting to achieve bone expansion as a technique for augmentation has received growing acceptance.[6,7]

In 1992, Simion et al.[11] was the first to introduce the split-crest bone manipulation technique. In his study, five patients displaying adequate vertical bone height but insufficient width of bone were chosen for treatment using the split-crest technique combined with guided tissue regeneration, followed by implant placement. The technique involved the splitting of the alveolar ridge longitudinally into two parts, creating a greenstick fracture. A chisel was then used to make a fine cut and split apart the two cortical plates and was followed by implant insertion. The implants and the existing defects were covered with guided bone regeneration (GBR) barriers. After osseointegration of the implants was assured, it was reported that the final increase in the width of the maxillary ridge was 3-4 mm while in the mandible it was 1-1.5 mm (this was attributed to the stiffness of the compact bone of the mandible). Histological examination of specimens obtained from the newly formed bone (using a trephine bur between the split cortical plates) revealed the regeneration of bone tissue of normal structure which was of little difference in mineralization rate from the pre-existing bone.[8]

The gap created in-between the split-crestal plates is utilized for the positioning of implants. The space unoccupied by the implants can be filled with biomaterials such as; autologous bone grafts, particulate bone, or plasma derivatives like platelet-rich plasma (PRP).[9,10] The advantages of ridge splitting when compared to other techniques were proven. Secondary surgical sites are not mandatory, and immediate implant placement can be accomplished during the procedure. The method allows for prostrate dilatation of the vestibular and palatal crest walls, providing a bone bed of mesenchymal cells from marrow origin therefore possessing a strong osteogenic potential that can assist the regenerative process without the need to use autologous donor zones. Favorable results are thus reached, with high predictability and low morbidity compared with those techniques that utilize autologous donor sites.[11,12] Another clinical study conducted on ridge splitting techniques featured the immediate placing of implants for restoration of single maxillary anterior teeth. It was reported that splitting is indicated for narrow ridges where sufficient spongy bone is found between labial and palatal cortices. The study described the bone-splitting procedure as a safe and predictable technique when carefully performed on selected patients, with the use of proper instrumentation.[13]

As previously highlighted, the split-crest technique is a flexible technique that allows many

Figure 1: Intraoral photograph showing the creation of bone channel using the piezoelectric surgical tip.

Figure 2: Intraoral photograph reporting the use of the 3.25 mm Ultra drill for implant site osteotomy.

modifications. Such modifications are performed with a choice of devices for the cutting of bone. The most common instruments implemented were fissure burs,[14] micro-saw/discs,[15,16,17] osteotome chisels[6,14,18,19] and piezo-electric knives.[12,16,19,20,21] Piezoelectric bone surgery was introduced to the dental profession in order to perform precise and minimally traumatic bone surgeries. This ultrasonic device provides the capability to cut mineralized hard tissues such as bone accurately and in a very safe way, with minor tissue damage.[22, 23, 24] Soft tissues such as nerves, blood vessels, or the Schneiderian membrane are not affected by the cutting tip because of their capability to oscillate at the same speed and amplitude as the tip. Various clinical contemplates have reported the potential use of ultrasonic bone surgery in the splitting and expansion technique with satisfactory results in most cases.[25] The aim of the present study is to clinically evaluate the suitability of piezoelectric bone surgery when adopted for a modified approach to the split-crest technique in the maxilla in combination with simultaneous implant placement. The approach presented herein provides an increase to the ridge width through the use of tapered implants and without the use of any defect filling materials.

PATIENTS AND METHODS

This study was conducted on 28 patients (18 males and 10 females) with an age range of 27- 58 years and a mean age of 38.4 ± 2.37. A total of 56 implants were placed in the selected patients. The patients were selected from the outpatient clinic at the Faculty of Oral and Dental Medicine, Cairo University. The study protocol was reviewed and approved by the Ethical Committee at the Faculty of Oral and Dental Medicine, Cairo University. Patients were chosen according to the following inclusion criteria: one or more missing teeth in the maxilla, the alveolar ridge in the edentulous site demonstrated insufficient bucco-palatal ridge width (less than 6 mm) with more than 10 mm of residual bone height and sufficient verti-

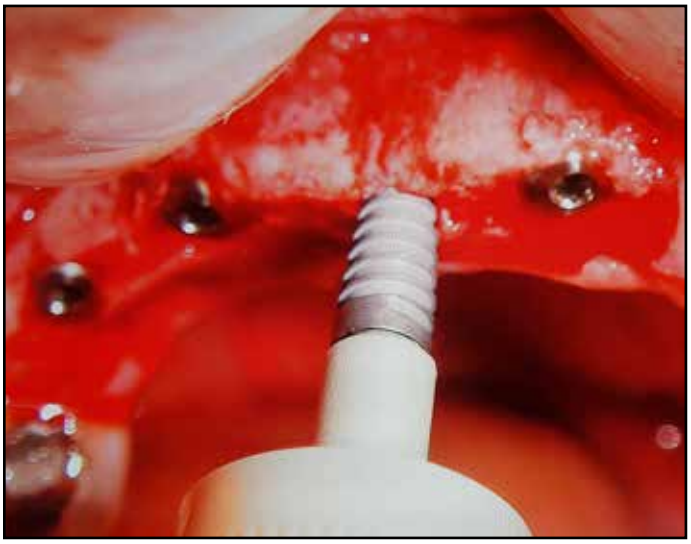

Figure 3: Intraoral photograph showing implant placement creating bone expansion during seating.

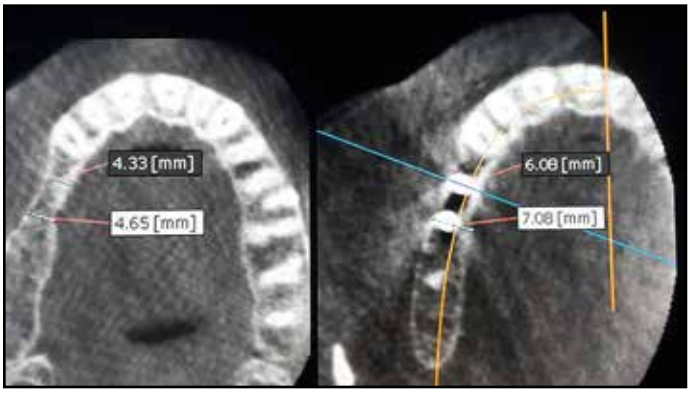

Figure 4: Pre-surgical and post-surgical (6 months) CBCT scan showing increased ridge width and positioned dental implants.

cal inter-maxillary arch space, upon centric occlusion. Exclusion criteria were: presence of any local or systemic condition that may contraindicate minor oral surgeries, active growth stage with partially erupted teeth and presence of oral habits that might endanger the osseointegration process, such as smoking or parafunctional habits.

All patients participating in the study were fully informed of the study protocol

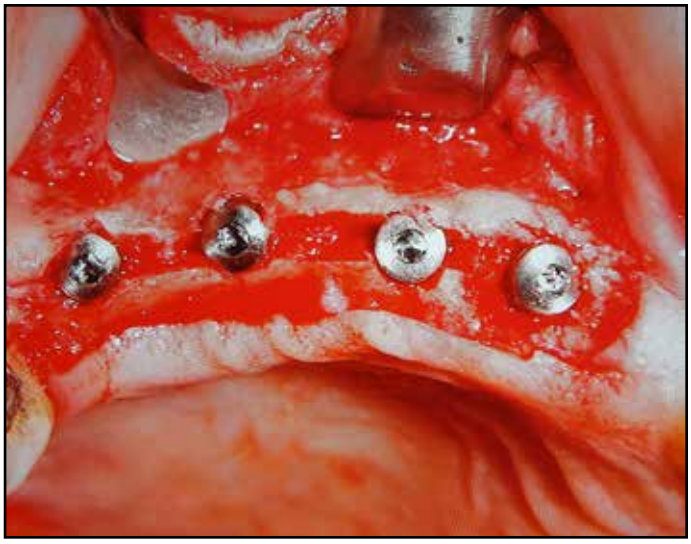

Figure 5: Dental implants with fixed cover screws.

and the associated risks of the study procedures. All participants signed an informed consent form to document their approval.

Pre-surgical evaluation included visual examination and palpation of the entire oral and para-oral tissues. Study casts were prepared to evaluate the inter-maxillary space and type of occlusion. The bucco-palatal alveolar ridge width at the implant site was measured using a bone caliper. Periapical and panoramic radiographs for the recipient site were taken. Cone Beam Volumetric Tomography (CBVT) was performed on the assigned sites for the study in order to determine the bucco-palatal alveolar ridge width at the implants' site.

Surgical Procedures

Patients were anesthetized locally by infiltration anesthesia. A palatal sub-crestal incision was created for the surgical site. Two oblique releasing incisions were then created on the buccal aspect. Dissection of the full thickness mucoperi-

Figure 6: Intraoral photograph showing soft tissue healing at 6 months after initial surgery.

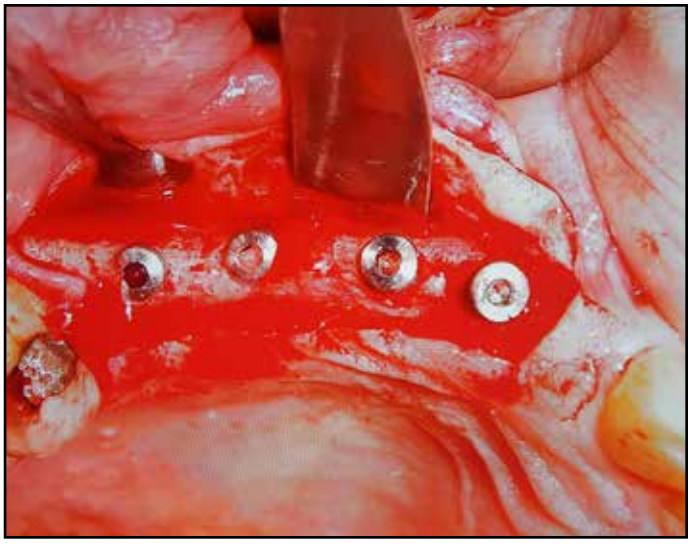

Figure 7: Intraoral photograph with the re-entry 6 months after initial surgery with complete bone fill and regeneration.

osteal flap was performed providing complete exposure of the alveolar bone. Using piezoelectric surgery unit (tip model: SG1, NSK Variosurg ultrasonic surgical system, Japan) a horizontal crestal cut was produced along the crest of the bone (Figure 1). The cut depth extended through the cortical bone to reach the spongy bone. The depth of the horizontal cut was approximately 1 mm shorter than the overall length of the implant to be placed. Two vertical cuts were made and these were connected to the horizontal crestal cut (except in two patients having a long span ridge for which vertical cuts were not needed). After ridge splitting, the osteotomy site was prepared using a 3.25 mm Ultra drill (Figure 2) and OsteoCare™ Maxi Z (OsteoCare™ Implant System, London, United Kingdom) two-piece and Maxi Z flat-end tapered dental implants were placed according to the manufacturer's protocol (Figure 3). Careful screwing and seating of these tapered implants into the bone was performed until all exposed threads were submerged and the platform remained flush with the crestal bone. This positioning of the implants created expansion through deformation between the split bony plates (Figure 4). Cover screws were then fixed to the implants (Figure 5). Closure of the flap was performed using interrupted sutures with a 4-0 black silk suture material (Assut sutures®. Switzerland).

Post-surgery Patient Management

1. Augmentin® (Medical Union Pharmaceuticals Co. Egypt) 1g tablets were prescribed twice daily for 5 days.
2. Analgesics were prescribed as following: Voltaren® (Novartis Pharma, S.A.E., Cairo, Egypt) 75 mg IM once.
3. Brufen® (Khaira Pharmaceuticals and Chemical Industries Company, Cairo, Egypt) 200 mg t.d.s for 5 days was prescribed.
4. Oral hygiene recommendations were provided including the use of soft toothbrush.

The Second Stage

After a healing period of 6 months (Figure 6), surgical re-entry was undertaken in order to assess the clinical success of the modified split-crest technique and to position the healing collars on the newly exposed implants (Figure 7).

Prosthetic Procedures

Ten days after positioning of the healing collars, indirect impressions were taken using OsteoCare™ impression transfers for the open tray transfer technique. Impressions were provided to dental laboratories for construction of the final porcelain-fused-to-metal or porcelain-fused-to-Zirconium crowns. After fixation of the abutments, the final crowns were permanently cemented using zinc phosphate cement.

Follow-Up Evaluation and Success Criteria

Every patient underwent immediate 'post surgery' evaluation and examination and again 6 months post-operatively. The examination and evaluation criteria included review for: absence of peri-implant infection, no complaint of local pain at the site of treatment and no complaint of neuropathies or paraesthesia. In addition the patients were evaluated for absence of clinically detectable mobility. Periotest M (Periotest® M, Medizintechnik Gulden, Bensheim, Germany) was used to test implant stability at 6 months before cementing the crowns.

Radiographic Evaluation

Standardized periapical radiographs using the parallel technique in addition to panoramic radiographs and CBVT were undertaken pre-operative, immediately post-operative (within the first 24 hours) and 6 months post-operative.

CBVT scans were used to evaluate the total gain in alveolar ridge width, in the bucco-palatal dimension. They were also used to assess the stability of the marginal bone around the implant after the procedure and to record the post-operative ridge width. The raw data obtained from the CBVT scan was imported into bespoke third party software for secondary reconstruction and further clinical interpretation. The results obtained from each of the data sets were compared. The pre-operative image was fused to the postoperative image by manual registration through landmarks in the cranium. Accurate registration (superimposition) was automatically performed by the software. Each image (primary and secondary) was color coded for identification. Firstly, key point measurements were recorded onto the primary image. The measurements on the primary image were held and the primary image was removed to leave the secondary image. New measurements were then recorded on the secondary image in the identical plane, direction and cut as that of the primary image to ensure standardization. The obtained data was then subjected to statistical analysis.

Statistical Analysis

Numerical data were displayed as mean ± standard deviation (SD) values. Qualitative data were presented as frequencies and percentages. Paired student t-test was conducted to compare the pre and the post-operative ridge widths. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with SPSS 18.0, Chicago, IL, USA.

RESULTS

A total of 56 implants were placed in 28 pre-selected patients. Six patients received one

Table 1: The Comparison Between Pre- and Post-operative Ridge Widths		
Pre-operative width Mean ± (SD)	**Post-operative width Mean ± (SD)**	**ρ-value**
4.52 ± 0.41	**7.44 ± 0.42**	**0.0001***
* Statistically significant different, p-value ≤ 0.05		

implant; 17 patients received two implants; three patients received three implants and two patients received 4 implants. The diameter of 53 of the implants was 3.75 mm and 3 implants had a diameter of 4.5 mm. The length of 43 implants was 13 mm and length of the remaining 13 implants was 10 mm. Wound healing was normal in all patients without any signs of infection, suppuration or mucositis. Initial pain and minor swelling was noted in all patients. These conditions were completely resolved by the tenth day post-operatively.

The preoperative ridge width of the patients ranged between a minimum of 3.58 mm and a maximum of 5.12 mm with the mean ± SD ridge width of 4.52 ± 0.41 mm. The 6 months postoperative ridge width ranged between a minimum of 6.46 mm and a maximum of 8.15 mm with a mean value of 7.44 ± 0.42 mm. The mean increase of the maxillary ridge width was 2.93 ± 0.13. Statistical analysis revealed a significant increase in the ridge width measurements with a *p*-value of 0.0001 (Table 1). All the implants were successfully osseointegrated when clinically tested at 6 months postoperatively. The degree of implant stability measured by Periotest M ranged between -2.3 and -5.3 after 6 months postoperatively.

DISCUSSION

Ridge split-crest bone manipulation technique is one form of augmentation procedures for narrow ridges. This procedure can be used for ridge expansion with immediate implant placement, providing an overall reduction in the time required for implant therapy.[26] Since the introduction of this technique various studies have reported the use of osteotomes and ridge expanders to increase ridge width for the placement of implants with successful outcomes.[27,28,29]

In the current study, tapered implants were used to expand the bone instead of using ridge expanders or osteotomes and this was considered as a valuable modification to the split-crest technique. Tapered implants provide more control over the expansion procedure by easing the bone plates apart in a gradual manner which minimizes the risk of fracturing the buccal plate. The expansion of the ridge and placement of the implants are combined into a single procedure. Few instruments were employed: the piezoelectric cutting tip, the tapered drill and the tapered, self-tapping, self-drilling implants which are placed into predetermined osteotomies within the split channel. No bone grafts or barriers were used to aug-

ment the osteotomy site. The self-space-making nature of the split channel allowed for natural bone regeneration by the osteogenic cells.[30]

The results of the current contemplate revealed a total mean maxillary ridge bone gain of 2.93 mm after 6 months post-operative, with no use of bone graft material or barrier membrane to fill the defect gap. The 100% success rate of the present study coincides with the results of several studies which have reported satisfactory ridge bone gain without the use of grafting materials. Chiapasco et al.[31] reported a final mean bone gain of 4 mm and Holtzclaw et al.[32] showed a mean bone gain of 4.03 mm. Meanwhile, Sohn et al.[33] reached a bone gain of 2.7 mm.

Various studies of the split-crest technique using osteotomes or bone expanders with bone grafts and/or barrier membranes to fill the remaining defect gaps have been reviewed.[30,34] Sethi et al.[29] reported the use of autologous bone and hydroxyapatite achieving a total gain of ridge width of 2.8 mm. Anitua et al.[30] used a barrier membrane and platelet rich growth factor achieving a final mean bone gain of 3.35 mm. Blus et al.[35] reached a final mean bone gain of 2.7 mm after combining allograft and PRP together with using a barrier membrane. Rahpeyma et al.[36] only used allograft and reached a mean bone gain of 2 mm. The survival rate of the implants in these studies collectively ranged between 95.3-100 %.

Our results documented a reduction in instrumentation used during the surgical procedures and the lack of requirement for using of any additional augmentation materials while still achieving a similar level of bone gain. The tapered design of the implants initiated the expansion of bone without the need of osteotomes or expanders.

In this contemplate, ridge splitting and implant placement were undertaken during the same visit as followed in other studies[1, 37] that stated ridge splitting with simultaneous implant placement as the preferable procedure when used in the maxilla, due to the thinner cortical plates and the softer medullary bone which provided easier and controlled expansion.[26]

The use of piezoelectric tips was successfully documented assuring the precise cutting of bone with preservation of the surrounding soft tissues, which was in accordance with other studies.[18,38,39,40]

CONCLUSION

The results of this study showed that the modified approach to split -crest technique as presented, is a successful technique for augmenting narrow maxillary ridges. This modification utilized a fewer number of instruments with the implants acting as bone expanders. Simultaneous implant placement was performed without the need for any grafting materials or use of GBR barriers.

Correspondence:
Dr. Basma Mostafa
Assistant Professor of Oral Medicine and Periodontology,
Surgery and Oral Medicine Dep.,
Oral and Dental Research Division, National Research Centre.
33 El Bohouth Street,
12622 Dokki, Cairo, Egypt.
e-mail: boshta@hotmail.com
Tel no.: 0020237623537
Fax no.: +20233387803.

Disclosure
Prof. Amr Zahran is the scientific consultant for OsteoCare™ Implant System (UK) and is involved in the designing of the whole range of the Maxi Z dental implants. All other authors claim to have no financial interest in this product.

References

1. Mechery R, Thiruvalluvan N, Sreehari AK. Ridge split and implant pacement in deficient alveolar ridge: Case reportand an update. Contemp Clin Dent 2015; 6: 94-7.
2. Sethi A, Kaus T. Ridge augmentation using mandibular block bone grafts: preliminary results of an ongoing prospective study. Int J Oral Maxillofac Implants 2001; 16: 378-88.
3. Holmquist P, Dasmah A, Sennerby L, Hallman M. A new technique for reconstruction of the atrophied narrow alveolar crest in the maxilla using morselized impacted bone allograft and later placement of dental implants. Clin Implant Dent Relat Res 2008; 10: 86–92.
4. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: a clinical and radiographic 12-month prospective study. The International Journal of Periodontics & Restorative Dentistry 2003; 23: 313–23.
5. Aghaloo TL, Moy PK. Which hard tissue augmentation techniques are the most successful in furnishing bony support for implant placement? The International Journal of Oral & Maxillofacial Implants 2007; 22: 49–70.
6. McAllister BS, Haghighat K. Bone augmentation techniques. Journal of Periodontology 2007; 78: 377–96.
7. Machtei EE. The effect of membrane exposure on the outcome of regenerative procedures in humans: A meta-analysis. J Periodontol 2001; 72: 512–16.
8. Laino L, Iezzi G, Piattelli A, Lo Muzio L, Cicciu M. Vertical ridge augmentation of the atrophic posterior mandible with sandwich technique: Bone block from the chin area versus corticocancellous bone block allograft: clinical and histological prospective randomized controlled study. Biomed Res Int 2014; 982104.
9. Herford AS, Tandon R, Stevens TW, Stoffella E, Cicciu M. Immediate distraction osteogenesis: The sandwich technique in combination with rhBMP-2 for anterior maxillary and mandibular defects. J Craniofac Surg 2013; 24: 1383–87.
10 Tatum H, Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986; 30: 207-29.
11. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associated with a split-crest technique and guided tissue regeneration. Int J Periodontics Restorative Dent 1992; 12: 462–73.
12. Guirado JLC, Yuguero MRS, Carrion del Valle MJ, Zamora GP. A Maxillary Ridge-Splitting Technique Followed by Immediate Placement of Implants: A Case Report. J Implant dent 2005; 14: 14 -20.
13. Anitua E, Andia I, Ardanza B, Nurden P, Nurden AT. Autologous platelets as a source of proteins for healing and tissue regeneration. Thromb Haemost 2004; 91:4-15.
14. Han JY, Shin SI, Herr Y, Kwon YH, Chung JH. The effects of bone grafting material and a collagen membrane in the ridge splitting technique: an experimental study in dogs. Clin Oral Impl Res 2011; 22 1391-98.
15. Suh JJ, Shelemay A, Choi SH, Chai JK. Alveolar ridge splitting: a new microsaw technique. Int J Periodontics Restorative Dent 2005; 25:165-71.
16. Blus C, Szmukler-Moncler S. Split-crest and immediate implant placement with ultra-sonic bone surgery: a 3-year life-table analysis with 230 treated sites. Clin Oral Implants Res 2006; 17: 700-7.
17. Engelke WG, Diederichs CG, Jacobs HG, Deckwer I. Alveolar reconstruction with splitting osteotomy and microfixation of implants. Int J Oral Maxillofac Implants 1997; 12: 310-8.
18. Anitua E, Begona L, Orive G. Controlled ridge expansion using two stage split crest technique with ultrasonic bone surgery. Implant Dent 2012; 21:163-70.
19. Shimoyama T, Kaneko T, Shimizu S. Ridge widening and immediate implant placement: A case report. Implant Dent 2001; 10:108.
20. Guirado C, Pardo Za mora G, Saez Yuguero MR. Ridge splitting technique in atrophic anterior maxilla with immediate implants, bone regeneration and immediate temporisation: a case report. J Ir Dent Assoc 2007; 53: 187-90.
21. Khoury F, Happe A, Hoppe A. Soft tissue management in oral implantology: a review of surgical techniques for shaping an esthetic and functional periimplant soft tissue structure. Quintessence International 2003; 31: 483-99.
22. Palti A. Ridge splitting and implant techniques for the anterior maxilla. [Interview]. Dent Implantol Update 2003; 14: 25-32.
23. Piccinini M. Mandibular bone expansion technique in conjunction with root form implants: A case report. J Oral Maxillofac Surg 2009; 67: 1931-36.
24. Crosetti E, Battiston B, Succo G. Piezosurgery in head and neck oncological and reconstructive surgery: personal experience on 127 cases. Acta Otorhinolaryngol Ital 2009; 29: 1–9.
25. Kelly A, Flanagan D. Ridge Expansion and Immediate Placement with Piezosurgery and Screw Expanders in Maxilary Atrophic Sites: Two Case Reports. J Oral Implantol 2013; 39: 85-90.
26. Agrawal Deepak, Alka Sanjay Gupta, Vilas Newaskar, Amit Gupta, Subhash Garg, Deshraj Jain. Narrow Ridge Management with Ridge Splitting with Piezotome for Implant Placement: Report of 2 Cases. J Indian Prosthodont Soc 2014; 14: 305–9.
27. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique : a five year study. Int J Periodontics Restorative Dent 1994; 14: 451-9.
28. Summers RB. The osteotome technique: Part 4-Future site development. Compend Contin Educ Dent 1995; 16: 1090-92.
29. Sethi A, Kaus T. Maxillary ridge expansion with simultaneous implant placement: 5-year results of an ongoing clinical study. Int J Oral Maxillofac Implants 2000; 15: 491-9.
30. Anitua E, Begoña L, Orive G. Clinical evaluation of split-crest technique with ultrasonic bone surgery for narrow ridge expansion: Status of soft and hard tissues and implant success. Clin Implant Dent Relat Res 2013;15: 176-87.
31. Chiapasco M, Ferrini F, Casentini P, Accardi S, Zaniboni M: Dental implants placed in expanded narrow edentulous ridges with the extension crest device. A 1-3-year multicenter follow-up study. Clinical Oral Implants Research (2006); 17:265–72.
32. Holtzclaw DJ, Toscano NJ, Rosen PS. Reconstruction of posterior mandibular alveolar ridge deficiencies with the piezoelectric hingeassisted ridge split technique: A retrospective observational report. J Periodontol 2010; 81:1580–6.
33. Sohn DS, Lee HJ, Heo JU, Moon JW, Park IS, Romanos GE. Immediate and delayed lateral ridge expansion technique in the atrophic posterior mandibular ridge. J Oral Maxillofac Surg 2010; 68: 2283–90.
34. Crespi R, Capparè P, Gherlone EF. Electrical mallet provides essential advantages in split-crest and immediate implant placement. Oral Maxillofac Surg 2014;18: 59-64.
35. Blus C, Szmukler-Moncler S, Vozza I, Rispoli L, Polastri C. Split-crest and immediate implant placement with ultrasonic bone surgery (piezosurgery): 3-year follow-up of 180 treated implant sites. Quintessence Int 2010; 41: 463-9.
36. Rahpeyma A, Khajehahmadi S, Hosseini VR. Lateral ridge split and immediate implant placement in moderately resorbed alveolar ridges: How much is the added width? Dent Res J (Isfahan) 2013; 10: 602–8.
37. Ella B, Laurentjoye M, Sedarat C, Masson E, Rouas A. Mandibular Ridge Expansion Using a Horizontal Bone-Splitting Technique and Synthetic Bone Substitute: An Alternative to Bone Block Grafting? Int J Oral Maxillofac Implants 2014; 29:135-40.
38. Schlee M, Steigmann M, Bratu E, Garg AK. Piezosurgery: basics and possibilities. Implant Dent 2006;15: 334-40.
39. Brugnami F, Caiazzo A, Mehra P. Piezosurgery-Assisted, Flapless Split Crest Surgery for Implant Site Preparation. J Maxillofac Oral Surg 2014;13: 67-72.
40. Bassetti R, Bassetti M, Mericske-Stern R, Enkling N. Piezoelectric alveolar ridge-splitting technique with simultaneous implant placement: a cohort study with 2-year radiographic results. Int J Oral Maxillofac Implants 2013;28:1570-80.