Original Article

Alveolar ridge split and expansion with simultaneous implant placement in mandibular posterior sites using motorized ridge expanders – modified treatment protocol

ABSTRACT

Purpose: "The purpose of the study is to evaluate alveolar ridge split and expansion (ARSE) with simultaneous implant placement in mandibular posterior implant sites using motorized ridge expanders."

Background: The ARSE is used in the management of horizontally deficient (narrow) alveolar ridge with optimum bone height available. The ARSE procedure in the posterior mandible has limited application as per literature. The successful cases reported are with extensive procedure of the osteo-mobilization with four corticotomies on buccal side. The authors presented the study of mandibular posterior implant sites using motorized ridge expanders. The ARSE performed here was by only crestal osteotomy simple osteo-condensation and immediate implant insertion.

Materials and Methods: The study was prospective type. The sample size was 15 patients and 31 implant sites. The study population included partially edentulous patients between 18 years and 60 years indicated for implant-supported prosthesis. The outcome variables studied included gain in ridge width, cervical bone loss, success of implant, and survival rate. Successful surgical outcome was evaluated by Buser's criteria. The data collected was evaluated by differential statistics.

Conclusion: The minimally invasive technique of one-stage ARSE performed with motorized ridge expander and insertion of implant in the same operative procedure decreases the morbidity, treatment time, number of surgical procedures, and the risk of complications, thereby, increasing patient acceptance. In this study, the authors have used this technique in the posterior mandible for narrow ridges (minimum 3 mm) and obtained promising results. The survival rate of the implants was 100% and the gain in ridge width was 3.2 mm. The author has also recommended the protocol according to bone density of mandible.

Keywords: Alveolar ridge split and expansion, bone density, horizontal ridge deficiency, immediate implant, mandible, motorized ridge expanders, narrow ridge, one stage ridge split, ridge width

Varsha S Manekar, S. R. Shenoi[1], Sunil Manekar[2], Janice Jhon[3]

Department of Oral and Maxillofacial Surgery (OMFS), Government Dental College and Hospital, [1]Department of OMFS, VSPM, Dental College and Research Centre, [2]Private Practice and Dental Laboratory, Manekar's Multispeciality Dental Clinic, Sidheshwar Dental and Ceramic Laboratory, Nagpur, [3]Department of OMFS, Yogita Dental College and Hospital, Ratnagiri, Maharashtra, India

Address for correspondence: Dr. Varsha S Manekar, Department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Nagpur - 441 401, Maharashtra, India. E-mail: varsha_manekar@yahoo.co.in

Received: 10 June 2021, **Revised:** 31 August 2021, **Accepted:** 15 September 2021, **Published:** 22 July 2022

INTRODUCTION

The horizontally deficient or narrow alveolar ridge is a common clinical finding. Various surgical procedures are performed to facilitate implant placement in these deficient sites, namely guided bone regeneration, onlay grafting, ridge split with expansion, and distraction osteogenesis. Each procedure has its own application with predictable results.

The alveolar ridge split and expansion (ARSE) technique is used in the management of horizontally deficient (narrow)

Access this article online	
Website: www.njms.in	Quick Response Code
DOI: 10.4103/njms.njms_417_21	

How to cite this article: Manekar VS, Shenoi SR, Manekar S, Jhon J. Alveolar ridge split and expansion with simultaneous implant placement in mandibular posterior sites using motorized ridge expanders – modified treatment protocol. Natl J Maxillofac Surg 2022;13:411-20.

alveolar ridge with optimum bone height. The alveolar ridge is split at the crest length wise, thereby, separating the buccal and lingual alveolar cortical plates using specialized instruments. It is a technique sensitive procedure. The instruments used for ridge split include surgical blade, thin bur, chisel/osteotomes, rotating/oscillating saw, and piezo tips. The split is followed by expansion using instruments such as osteotomes, chisels, or hand expanders.

The novel concept of ridge split was introduced by Tatum in 1986. Simion *et al*.,[1] and Scipioni *et al*.,[2] introduced the bone splitting technique using chisels for ridge expansion. Successful implant placement with ARSE can be achieved in alveolar bone with a width of 3 mm to 6 mm. At least 1 mm of trabecular bone should be present between the cortical plates for effective split. This will allow the bone to spread adequately on either side of the ridge without fracture and also maintain adequate blood supply.

Sethi and Kaus,[3] Kolerman,[4] Bruschi *et al*.,[5] Strietzel *et al*.[6] published successful use of osteotomes for ARSE by osteo-condensation whereas Blus *et al*.,[7] González-García *et al*.,[8] Mounir *et al*.[9] published their successful results for ARSE using osteotome with osteo-mobilization technique. The dental implant was inserted immediately after ARSE, in their study. Vercellotti[10] introduced piezoelectric surgery in dental implantology for ridge split technique.

Blus *et al*.,[7] Holtzclaw *et al*.,[11] Scarano *et al*.,[12] González-García *et al*.[8] used piezoelectric tips for osteotomies and osteotome/chisels were used for alveolar expansion followed by dental implant insertion immediately. However, Mahmoud *et al*.,[13] and Zahran *et al*.,[14] used piezo kit for split as well as for expansion of alveolar bone. Holtzclaw *et al*.,[11] Sohn *et al*.,[15] Scarano *et al*.,[12] Agabiti and Botticelli,[16] Gurler *et al*.,[17] Yao *et al*.[18] also used piezoelectric tips for the ridge split and chisel/osteotome as expansion device. The technique of ARSE was based on the principle of osteo-mobilization and immediate implant insertion.

Anitua *et al*.[19] published the study using motorized ridge expanders (MREs) for narrow alveolar ridge. Atraumatic bone expansion can be carried out with the MRE kits. Motorized ridge expansion kit is a newly introduced instrument. There are very few published studies that have evaluated the use of the MRE.

The mandibular alveolar ridge is dense. The edentulous mandibular ridges have thick cortices with decreased volume of vascular trabecular bone as compared to their maxillary counterparts. The lack of elasticity can be attributed to the mandibular posterior region having thicker cortical bone than the posterior maxilla.[20,21] According to literature, ARSE has been done in these sites with osteo-mobilization technique. This type of ARSE needs extensive surgical intervention. The implant diameter indicated for prosthetically driven implants in mandibular posterior implant sites is more than 4 mm. The ideal buccolingual width indicated is more than 7 mm.

The purpose of this prospective case series was to evaluate the results of the use of MRE in mandible using only crestal osteotomy and osteo-condensation method of ARSE. The aim was "to evaluate ARSE with immediate implant in mandibular posterior implant sites using motorized ridge expanders." The study population included partially edentulous patients between 18 years and 60 years indicated for implant-supported prosthesis reported between January 2018 and June 2019.

Method of selection of study subjects

Inclusion criteria

This study included patients between 18 years and 60 years indicated for implant-supported prosthesis in posterior mandible with adequate alveolar height (8–13 mm) and width 3–6 mm at prospective implant site. The patients selected were fit for minor surgery and implant prosthesis.

Exclusion criteria

Included patients unfit for minor oral surgery, implant sites not located in posterior mandible, insufficient vertical height of alveolar ridge, patients not consenting to participate in the study, alveolar ridge width <3 mm and more than 6 mm.

MATERIALS AND METHODS

A total of 15 patients with 31 implant sites were enrolled for this study. The cases were selected after necessary clinical and cone beam computed tomography (CBCT) evaluation. This study was approved by the Institutional ethics committee of our institution as a part of an ongoing extensive research on ARSE. Written informed consent was taken from all the participants. ARSE and implant insertion were then performed. The surgical procedure for all implants was performed by one senior and trained surgeon according to standardized protocol. For Ethical Clearance was obtained from our Institutional Ethical Committee with Ref no GDCHN/ 9547 /18 dated 31.12.2018.

The three-cornered flap with crestal incision and releasing mesial and distal incisions was taken. The mucoperiosteal flap was reflected to expose the buccal bone. The procedure also required a small flap reflection on the lingual side. The bony surgery started with the use of a ridge reducer for reducing the crest of narrow ridge approximately by 2 mm, thus exposing both the buccal and lingual cortices and intervening thin cancellous bleeding bone. The Buccolingual width of the implant site was measured with a ridge mapper. A 1.8-mm drill was used as the pilot drill to decided initial depth. Crestal osteotomy (ridge split) was performed with rotating saw from RSE kit (ESSET Kit). The use of serial motorized expanders of ESSET kit [as shown in Figure 1] according to manufacturer's instructions resulted in the expansion of alveolus. If the bone did not yield to the expansion, alternate bone tapping was needed. This was followed by the insertion of the implant and cover screw fixation. The ridge mapper was used to again measure the buccolingual width immediately after implant insertion. In cases of buccal bone dehiscence, augmentation of the buccal bone was done using allograft/alloplast. The soft tissue was closed primarily, followed by digital intra oral periapical Xray (IOPA), thus completing the surgical phase. The patients were prescribed antibiotic amoxicillin and clavulanic acid 625 mg, analgesic and anti-inflammatory twice a day for 5 days. After 6 months, digital IOPA was taken and healing abutment placed. This was followed by impression taking, prosthesis (ceramometal crown) fabrication, and screw-retained fixation. The participants were recalled for follow-up and evaluated both clinically and with digital IOPA after 6 months.

In the case illustrated in the images, the patient had an edentulous posterior mandible with missing 35, 36, and 37 as seen in Figure 2. Figures 3 and 4 show the CBCT cross section of 35 (B-L width 4 mm) and 36 (B-L width 6 mm) implant sites. Figure 5 shows the reflected mucoperiosteal flap and the horizontal crestal osteotomy. The use of serial expanders according to manufacturer's instructions resulted in the formation of implant sites and expansion indicated by increase in buccolingual width after crestal osteotomy [Figure 6]. After immediate insertion of the implants in 35, 36, and 37 sites, increase in the width of crestal osteotomy is better appreciated in Figure 7.

One more case has been shown in Figure 8 with clinical alveolar ridge of varying width in 45 and 46 sites. Figure 8 also shows the inserted implant in which the widened alveolar split in inter-implant part was seen. Digital IOPA radiographs were taken at the time of implant insertion [Figure 9], at the time of healing abutment insertion, 6 months postoperative [Figure 10] and 6 months after loading of the implant [Figure 11]. Successful osseointegration of the implants and the level of cervical bone maintained on the mesial and distal side of the implants were noted (B-L width 4 mm). The first patient treated was recalled for follow-up and evaluated periodically for 2 years after loading of prosthesis. Figure 12 shows the preoperative orthopantomogram (OPG) showing multiple missing teeth (43–48). The same surgical protocol was followed at 43, 44, and 46 sites, followed by an implant-supported bridge. The 2-year postoperative OPG [Figure 13] showed successful osseointegration of the implants. All the patients were evaluated for a minimum of 6 months after loading the prosthesis. Digital IOPA radiographs and Buser's criteria were used for evaluation of the success of the implant.

Figure 1: The motorized ridge split kit consisting of rotating saw and set of sequential drills

Figure 2: Clinical presentation of Case no 3 showing missing 35, 36, 37

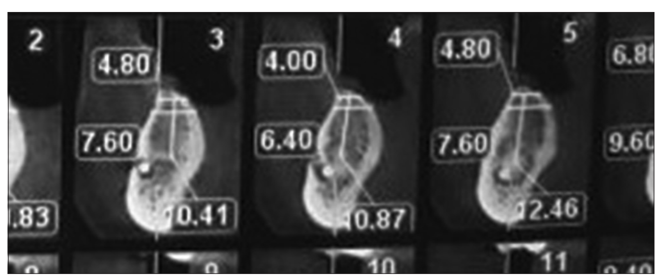


Figure 3: Cone beam computed tomography cross section of Case no 3 at dental implant site 35

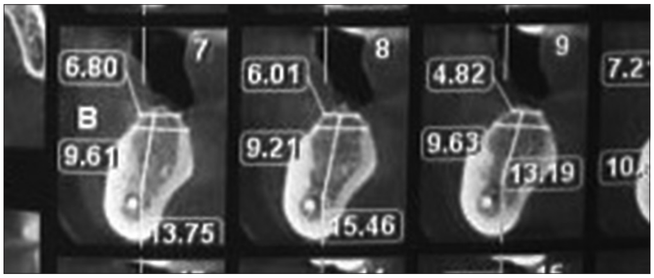


Figure 4: Cone beam computed tomography cross section of Case no 3 implant site 36

Figure 6: Intra-operative illustration after use of sequential expanders showing widened crestal osteotomy and implant site osteotomy of Case no 3

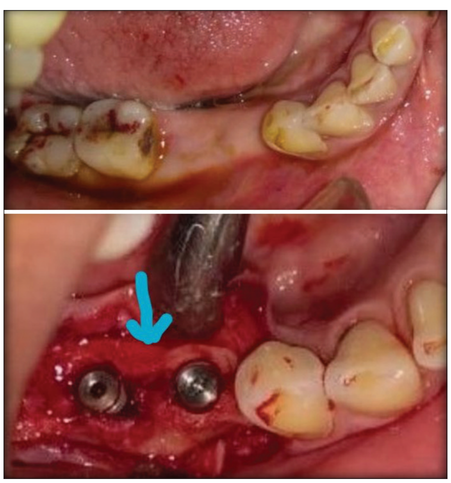


Figure 8: Illustration of Case no 5 showing intraoral missing 45, 46 and intra operative crestal split and implant with cover screw

The outcome variables (OV) studied included gain in ridge width, cervical bone loss, success of implant, and survival rate. Gain in ridge width (RWG) is equal to the difference in buccolingual width at cervical level measured after implant insertion (RW2) and the one measured by ridge mapper immediately after reflection (RW1) (RW2-RW1).

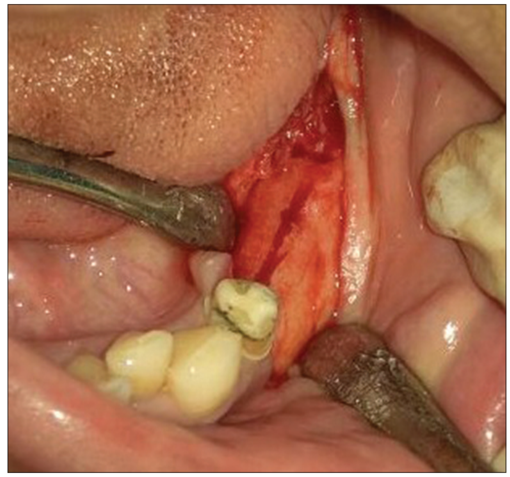


Figure 5: Implant site marking with pilot drill and crestal osteotomy in an intraoperative illustration of Case no 3

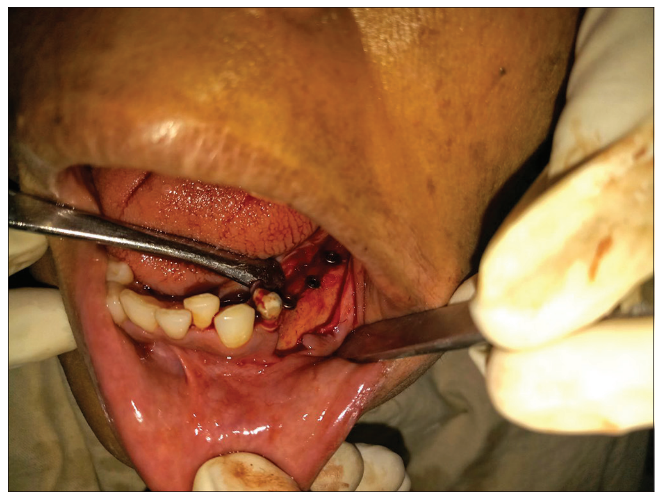


Figure 7: Intra-operative illustration showing the cover screw of implants inserted in implant osteotomy of Case no 3

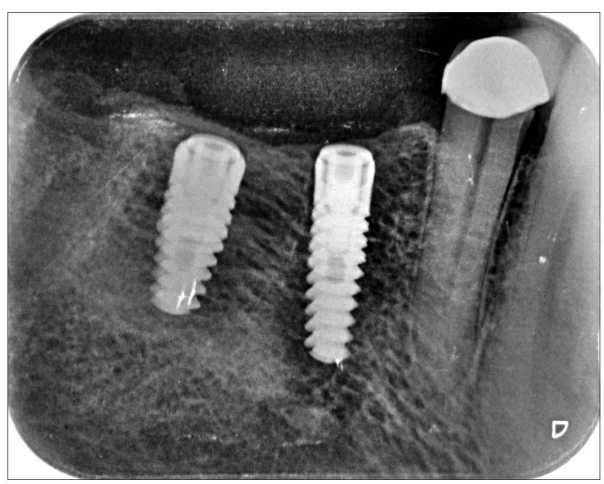


Figure 9: The digital intra-oral periapical image of Case no 5 taken after implant insertion showing two implants in 45, 46 sites

The cervical bone loss (second OV) was defined as the increase in distance between the upper-most point of

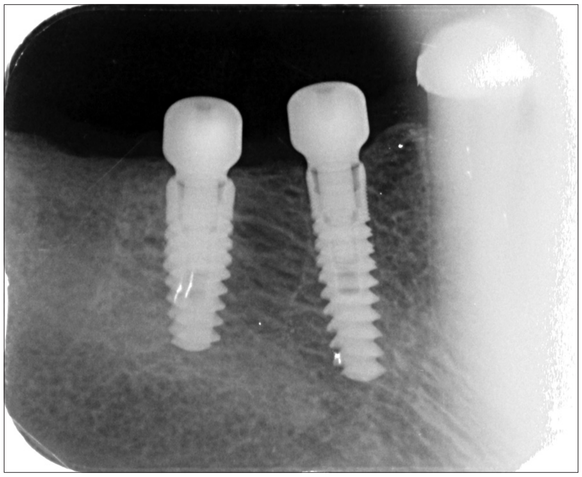


Figure 10: The digital intra-oral periapical image of Case no 5, 6-month postimplant insertion at the time of prosthetic loading showing good osseointegration and maintained cervical bone level

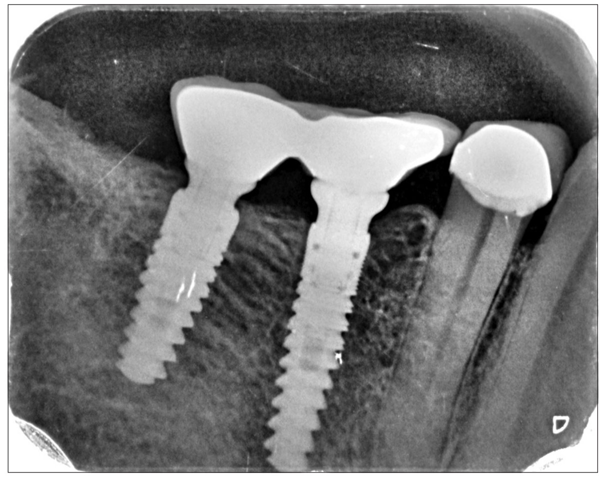


Figure 11: The digital intraoral periapical image of Case no 5, 6 months after prosthesis that is 1-year postimplant insertion showing good osseointegration and maintained cervical bone level

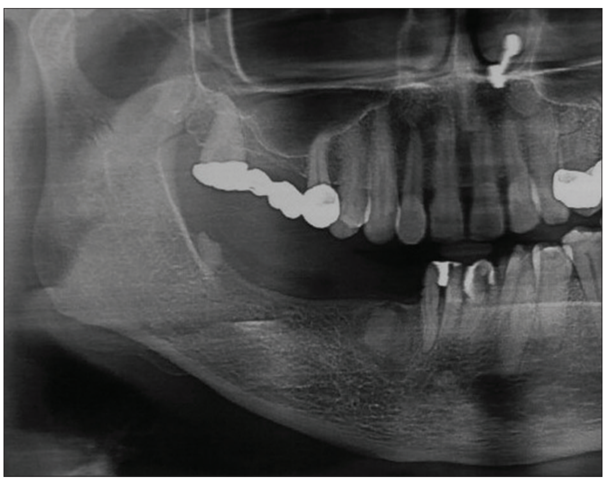


Figure 12: Orthopantomogram of Case no 1 showing missing teeth no 43 to 47

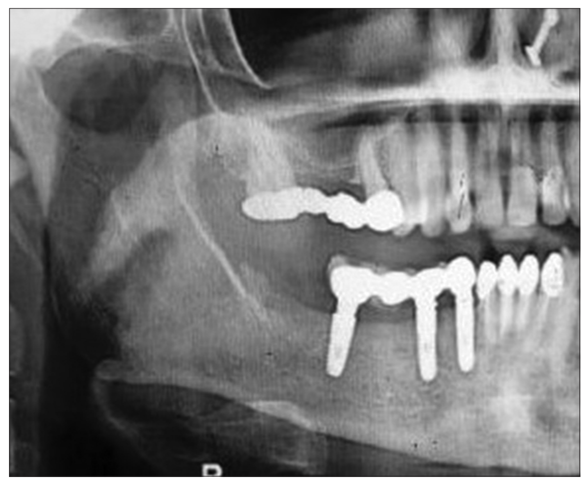


Figure 13: Orthopantomogram 3-year postprosthesis of Case no 1 showing implant with prosthesis in 43, 44, and 46 sites with maintained cervical bone level and good osseointegration

the implant platform and the most coronal contact of bone and implant (the reference value was this distance measured at the time of implant insertion) evaluated from digital IOPA (mesial and distal side). Cervical bone level was measured 6 months after implant insertion, at the time of prosthesis (CBL1), and 6 months after prosthesis (CBL2). For this purpose, the cervical level of bone (CBL0) at the time of insertion of implant was considered as the baseline.

Successful surgical outcome was evaluated by Buser's[22] criteria, 4 months after implant insertion and 6 months after placement of prosthesis.

This criteria include four parameters: (1) absence of clinically detectable implant mobility, (2) absence of pain or any subjective sensation, (3) absence of recurrent peri-implant infection, (4) absence of radiolucency around the implant. The survival rate was the number of successful implants 6 months after prosthesis fixation.

OBSERVATIONS AND RESULTS

The sample size was 31 implants in 15 participants. There were 3 male and 12 female participants. The mean age was 56.8 years. Twenty-two of osstem implants and 9 of myriad implant system. Table 1 shows the data of observations for RW1, RW2, RWG, implant size, CBL1, CBL2 (as explained in previous section). The 7 implant sites of Class II and 24 implant sites were of Class III according to recent classification of the alveolar ridge width with implant-driven treatment considerations for the horizontally deficient alveolar ridges by Tolstunov.[23] The data of alveolar ridge width and crestal bone level (mesial and distal side of all implants) of all implant sites are entered in Table 2.

Table 1: The demographics of the participants, implant sites, preoperative ridge width on CBCT cross section, and the type of ridge according to Tolstunov classification

Case number	Age in years	Gender	Implant site	Preoperative RW on CBCT (mm)	Classification of implant site according to Tolstunov classification	Type of bone as seen in CBCT according to [Table 4]
1	52	Female	44	3.4	III	Type 1
			46	5.3	III	Type 2
2	55	Female	36	5	III	Type 4
			45	5	III	Type 3
			46	6	II	Type 2
3	58	Female	35	4	III	Type 2
			36	6	II	Type 1
4	75	Male	35	5	III	Type 2
			37	4	III	Type 2
			45	4.7	III	Type 2
			47	5	III	Type 3
5	52	Female	45	6	II	Type 1
			46	6.5	II	Type 3
6	50	Female	45	5.3	III	Type 3
			46	6.3	II	Type 5
7	50	Female	36	4.2	III	Type 2
8	58	Female	37	5.6	III	Type 2
9	60	Male	46	4	III	Type 3
10	62	Female	36	5	III	Type 1
			46	5.4	III	Type 1
11	29	Female	46	6	II	Type 2
12	59	Female	36	5	III	Type 3
			46	4.8	III	Type 2
13	61	Female	35	4.9	III	Type 3
			36	4.2	III	Type 3
			37	5.1	III	Type 2
14	72	Male	46	6	II	Type 5
15	59	Female	46	4.2	III	Type 2
			47	5	III	Type 2
			36	5.1	III	Type 3
			37	4.2	III	Type 3

RW: Ridge width, CBCT: Cone beam computed tomography

All 31 implants were successful as per Bruser's criteria and survival rate of implant was 100%. The differential statistics was used. Analysis of data as per differential statistics is shown in Table 3. Mean preoperative ridge width is 5.1 mm. Mean ridge width gain is 3.2 mm and standard deviation (SD) is 0.6 mm. The mean implant size used is 4.2 mm. Table 3 shows that the mean crestal bone loss CBL1 on mesial side was 0.5 mm (SD 0.8). Mean CBL 2, on mesial and distal side was 0.5 (SD 0.6).

No intraoperative buccal wall fracture or dehiscence was observed. The postoperative recovery of the patients was uneventful and no exposure of the surgical area was occurred. All were screw-retained prosthesis. In the 6-month postloading prosthesis, loosening of screw occurred in one implant. No wound dehiscence and buccal bone fracture were observed.

DISCUSSION

Cullum[24] described two techniques of ARSE – "osteo-condensation" and "osteo-mobilization." The principle of ARSE initially described by Tatum and later by summers was by "osteo-condensation". This principle involved avoiding bone removal, lateral compression using osteotomes, and condensation of spongy maxillary bone. This results in increased periimplant bone density, increased bone to implant contact, and increased ridge width in osteotomy sites. Cullum described that rotary mechanical expanders use the modification of this "osteo-condensation" technique, thereby reducing surgical manipulation and patient awareness.

Osteo-mobilization as described by Cullum[24] involves the use of precise osteotomies of the residual alveolus to allow progressive intraoperative manipulation and outward mobilization of buccal bone, thereby increasing the horizontal dimension. This technique of RSE comprises of green-stick fracture or out fracture of the osteotomized buccal cortical plate with osteotome, chisels, and/or rotary mechanical expanders. This technique is especially used in

Table 2: Alveolar ridge width and crestal bone (mesial and distal side of all implants)

Case number	Implant site	Preoperative RW on CBCT (mm)	RW1 (mm)	Size of implant (mm)	RW2	RWG (mm)	CBL1 mesial	CBL1 distal	CBL2 mesial	CBL2 distal
1	44	3.4	4.2	4	7	2.8	0.5	0.5	1	1
	46	5.3	5	4.5	9	4	0.5	0.5	1	1
2	36	5	5	4	8	3	0	0	0.5	0.5
	45	5	5	4.5	9	4	0	0	0.5	1
	46	6	6	4.5	9	2	0	0	1	0
3	35	4	4.2	4.5	8	3.8	0.4	0.5	0	0
	36	6	6	4.5	9	3	0	0	0	0
4	35	5	5	4.5	9	4	0.8	0.8	1	1
	37	4	5	5	9	4	0.8	0	1	1
	45	4.7	5	4	8	3	0.3	0.4	0.8	0.8
	47	5	5	4	8	3	0.4	0.4	0.9	1
5	45	6	6	3.8	8	2	0	0	1.5	0
	46	6.5	6	4.5	9	3	0	0	0	1
6	45	5.3	5	4.5	9	4	0.4	0	0.8	0
	46	6.3	6	4.5	9	3	0	0.5	0	0.6
7	36	4.2	6	4.5	9	3	0	0.4	0	0.4
8	37	5.6	6	4.5	9	3	0.5	0	0.8	0
9	46	4	4	3.8	7	3	0	0.6	0	0.5
10	36	5	5	4.5	8	2	0	0	0	0
	46	5.4	5	4.5	9	4	0.5	0	0.5	0
11	46	6	6	5	10	4	0	0	0	0
12	36	5	5	4	8	3	0	0	0	0
	46	4.8	5	4	8	3	0	0	0	0
13	35	4.9	5	4	8	3	1	2	0	0
	36	4.2	4	4	7	3	3	3	0	1
	37	5.1	5	4	8	3	2	1	0.5	0.5
14	46	6	6	4.5	9	2	0	0	0	0
15	46	4.2	4	3.5	7	3	0	0.4	0	0
	47	5	5	4	8	3	0	0	0	0
	36	5.1	5	4.5	9	4	0.4	0.8	1	1
	37	4.2	4	4	8	4	3	2	3	3

RW: Ridge width, RW1: Buccolingual width measured with ridge mapper at implant site after mucoperiosteal flap reflection, RW2: Buccolingual width measured with ridge mapper at implant site after implant insertion, RWG: RW2−RW1, CBL1: Cervical bone level measured 6 months after implant insertion, at the time of prosthesis, CBL2: Cervical bone level was measured 6 months after prosthesis

mandible where the bone is dense. However, in this study, the authors have used osteo-condensation technique with MRE in the mandible. The resultant average gain in width of 3.2 mm was satisfactory and all implant sites had intact buccal cortical plates.

As compared to maxillary bone, mandibular bone has greater density that results in greater resistance during expansion of the buccal cortical plate, thus increasing the risk of fracture.[12] Goyal and Iyer[25] stated that green-stick fracture during widening is not controllable in the mandible because of greater cortical thickness of the bone and the risk of mal-fracture during single-stage expansion is high in this region. Thus, the mandible represents a greater challenge that requires increased caution during the performance of single-stage ridge splitting since the bone tissue elasticity is not appropriate for mechanical expansion.

In the present study, there was no dehiscence or fracture of buccal bone. Inability to split and expand due to high density of the alveolar bone (Type 4) in 1 case was managed by bone tapping along with ARSE. This procedure creates stresses at cervical bone, resulting in cervical bone loss. Anitua *et al*.,[26,27] published two studies of ARSE in the mandible based on the technique of sagittal osteotomy (crestal osteotomy) performed with ultrasonic scalpel followed by expansion with motorized expanders and immediate implant insertion in patients with ridge width of more than 3 mm. The gain in width was 3.35 mm in the 1st case while it was 2.3 mm in the 2nd case. The implant survival rate was 100%.

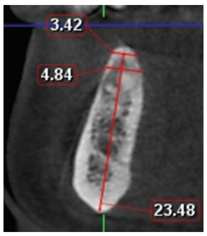
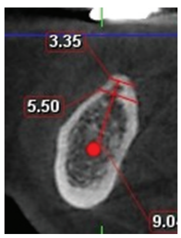
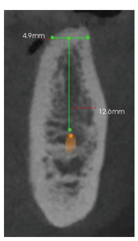
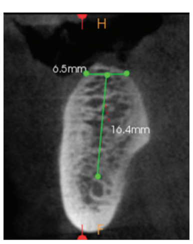
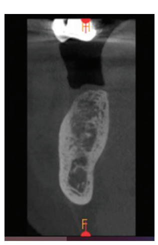
The ARSE technique used in our study is similar to the one described by Anitua with the only difference that a rotating saw was used instead of ultrasonic scalpel for the crestal osteotomy. The mean width gain was 3.2 mm.

Table 3: Differential statistics

Differential statistics	RW1	RW2	RWG	Implant size	CBL1 mesial	CBL1 distal	CBL2 mesial	CBL2 distal
Mean	5.109	8.387	3.180 (3.2 mm)	4.277	0.467	0.445	0.509	0.493
Median	5	8	3	4.5	0	0	0.5	0.4
Mode	5	9	3	4.5	0	0	0	0
SD	0.680	0.765	0.649	0.350	0.800	0.710	0.656	0.641

RW: Ridge width, SD: Standard deviation, RW1: Buccolingual width measured with ridge mapper at implant site after mucoperiosteal flap reflection, RW2: Buccolingual width measured with ridge mapper at implant site after implant insertion, RWG: RW2-RW1, CBL1: Cervical bone level measured 6 months after implant insertion, at the time of prosthesis, CBL2: Cervical bone level was measured 6 months after prosthesis

Table 4: Response of different alveolar bone types, with width of 3-6 mm on cone beam computed tomography to motorized alveolar ridge split and expansion, categorized by the authors

	Varying CBCT imaging of implant site	Interpretation of imaging	Response to motorized ARSE
Type 1		Buccal cortex 1-mm thick corticated lingual cortex D3-D4 type cancellous bone	Responds well to RSE
Type 2		Buccal cortex 2 mm thick Corticated lingual cortex D2-D3 type cancellous bone	Responds well to RSE
Type 3		Buccal cortex 3 mm thick Corticated lingual cortex D2 type cancellous bone	Responds moderately to RSE
Type 4		Highly dense; buccal cortex 3-4 mm thick Corticated lingual cortex D1 type cancellous bone	Difficult to split Do not respond to the osteocondensation Ridge expanders and tapping recommended Or osteomobilization recommended
Type 5		Varying density of buccal and lingual cortices with osteoporotic cancellous bone Highly radiolucent cancellous bone	Separation of split not seen, only osteocondensation occurs Possibility of buccal bone dehiscense

RSE: Ridge split and expansion, ARSE: Alveolar RSE, CBCT: Cone beam computed tomography

Jamil and Al-Adili[28] in their study used the technique of osteo-mobilization with piezo-cutting device and motorized expanders for expansion of the ridge. They also used synthetic bone substitute as fillers in the sagittal split region and guided bone regeneration. The implants were inserted immediately. The mean bone width gained in the mandible was 4.38 mm. In their study, complications were noted in 8 cases, of which 7 were in the mandible. They attributed this to the presence of highly dense cortical bone and sparse cancellous bone in this arch.

Many authors have recommended treatment with two-stage approach in the mandible. Sohn *et al*.,[15] concluded that delayed (2-stage) approach assures greater safety and predictability in patients having narrow ridge with denser and thicker cortices in the mandible. The strength of our study lies in “the success of implant insertion using single-stage ARSE with the minimally invasive approach of osteo-condensation,” performed by sequential noncutting drills of MREs and immediate implant insertion, significantly reducing the treatment duration in the horizontally deficient mandibular posterior region. The response of bone to MREs depends on the thickness of the cortical bone, especially on the buccal aspect and the thickness and quality of cancellous bone. As mentioned by Mazzocco F *et al*.,[29] a limited amount of cancellous bone might increase the amount of expansion, hence reducing the amount of possible bone condensation. Motorized expanders carry out the condensation of the cancellous bone as a result of absorbed part of the centripetal pressure generated by the expander. Simultaneously, the cortical plates are expanded to some extent. Thus, crestal osteotomy with the use of MRE leads to osteo-condensation and ridge expansion. The quality of bone is the deciding factor here. In this study, the authors have highlighted the response of the five different bone quality types to MRE noncutting drills, as mentioned in Table 4.

Holtzclaw *et al*.,[11] in the retrospective case series used piezo-electric hinge assisted ridge split procedure in the posterior mandible. The surgical procedure used here is osteo-mobilization and delayed implant insertion after 4 months. Although the ridge width gain was 4.1 mm and piezo-electric surgery is a good option for osteotomies, the two-stage approach and osteo-mobilization procedure involves extensive surgery and prolonged treatment duration. Bravi *et al*.,[30] in a multicentric retrospective clinical study of 1715 implants placed with edentulous ridge expansion observed that 44% of the implants placed in the mandibular sites required a two-stage procedure. They have described the mandibular bone as an “inelastic bone.”

From the authors’ experience, implant sites of Type 4 [Table 4] are difficult to split and do not respond to osteo-condensation. MREs along with tapping or osteo-mobilization are recommended in Type 4 alveolar bone. Other types of alveolar bone in the mandible respond well to the MRE. The mean cervical bone loss of only 0.5 mm shows that the cervical bone level is well preserved.

CONCLUSION

The minimally invasive technique of one-stage ARSE performed with MRE and insertion of implant in the same operative procedure decreases the morbidity, treatment time, number of surgical procedures, and the risk of complications, thereby, increasing the patient acceptance. In this study, the authors have used this technique in the posterior mandible for narrow ridges (minimum 3 mm) and obtained promising results. The survival rate of the implants was 100% and the gain in ridge width was 3.2 mm. However, clinical trials with bigger sample size and long-term follow-up are recommended. The author has also recommended the protocol according to bone density of mandible.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Simion M, Baldoni M, Zaffe D. Jawbone enlargement using immediate implant placement associate with a split crest technique and guide tissue regeneration. Int J Periodontics Restorative Dent 1992;12:462-73.
2. Scipioni A, Bruschi GB, Calesini G. The edentulous ridge expansion technique: A five-year study. Int J Periodontics Restorative Dent 1994;14:451-9.
3. 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.
4. Kolerman R, Nissan J, Tal H. Combined osteotome-induced ridge expansion and guided bone regeneration simultaneous with implant placement: A biometric study. Clin Implant Dent Relat Res. 2014;16:691-704. Epub 2013 Jan 25.
5. Bruschi GB, Capparé P, Bravi F, Grande N, Gherlone E, Gastaldi G, *et al.* Radiographic evaluation of crestal bone level in split-crest and immediate implant placement: Minimum 5-year follow-up. Int J Oral Maxillofac Implants 2017;32:114-20.
6. Strietzel FP, Nowak M, Küchler I, Friedmann A. Peri-implant alveolar bone loss with respect to bone quality after use of the osteotome technique: Results of a retrospective study. Clin Oral Implants Res 2002;13:508-13.
7. 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.
8. González-García R, Monje F, Moreno C. Alveolar split osteotomy for the treatment of the severe narrow ridge maxillary atrophy: A modified technique. Int J Oral Maxillofac Surg 2011;40:57-64.
9. Mounir M, Beheiri G, El-Beialy W. Assessment of marginal bone loss using full thickness versus partial thickness flaps for alveolar ridge splitting and immediate implant placement in the anterior maxilla. Int J Oral Maxillofac Surg 2014;43:1373-80.
10. Vercellotti T. Piezoelectric surgery in implantology: A case report – A new piezoelectric ridge expansion technique. Int J Periodontics Restorative Dent 2000;20:358-65.
11. Holtzclaw DJ, Toscano NJ, Rosen PS. Reconstruction of posterior mandibular alveolar ridge deficiencies with the piezoelectric

hinge-assisted ridge split technique: A retrospective observational report. J Periodontol 2010;81:1580-6.
12. Scarano A, Piattelli A, Murmura G, Iezzi G, Assenza B, Mancino C. Delayed expansion of the atrophic mandible by ultrasonic surgery: A clinical and histologic case series. Int J Oral Maxillofac Implants 2015;30:144-9.
13. Mahmoud ZT, El-Dibany MM, El-Ghamrawy SM, Osman SM, Troedhan AC. Piezoelectric ridge splitting using split thickness mucosal flap. Alexandria Dent J 2017;42:67-72.
14. Zahran A, Mostafa B, Hanafy A, Darhous M. A modified split-crest technique using piezoelectric surgery and immediate implant placement in the atrophic maxilla. J Implant Adv Clin Dent 2016;8:36-41.
15. 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.
16. Agabiti I, Botticelli D. Two-stage ridge split at narrow alveolar mandibular bone ridges. J Oral Maxillofac Surg 2017;75:2115.e1-12.
17. Gurler G, Delilbasi C, Garip H, Tufekcioglu S. Comparison of alveolar ridge splitting and autogenous onlay bone grafting to enable implant placement in patients with atrophic jaw bones. Saudi Med J 2017;38:1207-12.
18. Yao Y, He K, Gong P, Tang H. U-shaped bone splitting and osteotome techniques for narrow alveolar ridge in implant surgery. Implant Dent 2018;27:507-11.
19. Anitua E, Begoña L, Orive G. Two-stage split-crest technique with ultrasonic bone surgery for controlled ridge expansion: A novel modified technique. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:708-10.
20. Neiva RF, Gapski R, Wang HL. Morphometric analysis of implant-related anatomy in Caucasian skulls. J Periodontol 2004;75:1061-7.
21. Flanagan D. A comparison of facial and lingual cortical thicknesses in edentulous maxillary and mandibular sites measured on computerized tomograms. J Oral Implantol 2008;34:256-8.
22. Buser D, Mericske-Stern R, Bernard JP, Behneke A, Behneke N, Hirt HP, *et al.* Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. Clin Oral Implants Res 1997;8:161-72.
23. Tolstunov L. Classification of the alveolar ridge width: Implant-driven treatment considerations for the horizontally deficient alveolar ridges. J Oral Implantol 2014;40 Spec No: 365-70.
24. Cullum D. Advances in bone manipulation techniques: Part 2. Osteomobilization for horizontal and vertical implant site development. In: Selected Readings in Oral and Maxillofacial Surgery. Vol. 18. San Francisco, CA: Guild for Scientific Advancement in Oral and Maxillofacial Surgery; 2010. p. 5.
25. Goyal S, Iyer S. Bone manipulation techniques. Int J Clin Implant Dent 2009;1:22-3.
26. 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.
27. Anitua E, Alkhraisat MH. Is alveolar ridge split a risk factor for implant survival? J Oral Maxillofac Surg 2016;74:2182-91.
28. Jamil FA, Al-Adili SS. Lateral ridge splitting (Expansion) with immediate placement of endosseous dental implant using piezoelectric device: A new treatment protocol. J Craniofac Surg 2017;28:434-9.
29. Mazzocco F, Nart J, Cheung WS, Griffin TJ. Prospective evaluation of the use of motorized ridge expanders in guided bone regeneration for future implant sites. Int J Periodontics Restorative Dent 2011;31:547-53.
30. Bravi F, Bruschi GB, Ferrini F. A 10-year multicenter retrospective clinical study of 1715 implants placed with the edentulous ridge expansion technique. Int J Periodontics Restorative Dent 2007;27:557-65.