Research Article

Efficiency of osseodensification versus screw expansion technique for augmentation of narrow alveolar ridges: A comparative clinical study

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Abstract: Background: Alveolar ridge expansion is proposed when the alveolar crest thickness is ≤5 mm. The screw expansion technique has been utilized for many years to expand narrow alveolar ridges. Recently, the osseodensification technique has been suggested as a reliable technique to expand narrow alveolar ridges with effective width gain and as little surgical operating time as possible. The current study aimed to compare osseodensification and screw expansion in terms of clinical width gain and operating time. Materials and methods: Forty implant osteotomies were performed in deficient horizontal alveolar ridges (3–5 mm). A total of 19 patients aged 21–59 years were randomized into two groups: the screw expansion group, which involved 20 osteotomies performed by screw expander drills, and osseodensification group, which comprised 20 osteotomies achieved by osseodensification drilling technique. One millimetre below the alveolar bone crest was measured with a bone caliper at two intervals (before implant osteotomy and after implant osteotomy), and operating time was assessed. Results: Before expansion, the mean alveolar ridge width was 4.20 ± 0.71 mm in the osseodensification group and 4.52 ± 0.53 mm in the screw-expansion group. No statistically significant difference in alveolar bone width before expansion was found between the groups ($P > 0.05$). After the expansion of the alveolar ridge with osseodensification or screw expansion techniques, the average ridge width was 5.48 ± 0.57 mm in the osseodensification group and 5.71 ± 0.53 mm in the screw-expansion group. Difference in width gain postoperatively between the groups was 0.09 mm, which was not statistically significant ($P > 0.05$). According to operating time, osseodensification consumed 6.21 ± 0.55 minutes, and screw expansion required 16.32 ± 0.60 minutes for a single implant with a significant difference between the groups ($P < 0.0001$). Conclusion: Alveolar bone expansion by osseodensification showed comparable width gain and less surgical operating time compared with expansion by screw expansion technique.

Keywords: *Osseodensification, screw expansion, narrow alveolar ridge.*

Introduction

Alveolar ridge resorption following tooth extraction limits implant placement under conventional methods. After tooth extraction, a variety of events occur and cause changes in alveolar ridge dimensions, such as decreases in alveolar crest width and height [(1)]. Up to 50% of the total alveolar bone volume is lost

during the early stages of repair [2]. In general, 3.79 mm horizontal and 1.24 mm vertical bone resorption occur in the first 6 months after tooth extraction [3].

Bone augmentation is necessary during ridge resorption because it ensures sufficient bone volume, provides patients with appropriate inter-arch proportions, and ensures a positive esthetic result [4]. To obtain a sufficient ridge volume for implant insertion and prosthodontic rehabilitation, numerous reconstruction methods have been proposed to augment horizontal alveolar bone dimensions, including osteotome expansion, ridge splitting, distraction osteogenesis, and guided bone regeneration [5–8]. Most of these methods have success rates of less than 100%, waiting periods of 6–12 months, greater morbidity, and high treatment costs and require a second operation site [9]. To increase the bone volume and the simultaneous installation of implants, bone augmentation can be performed by alveolar ridge expansion approach utilizing screw expansion (SE) or osseodensification (OD) [10, 11].

Siddiqui and Sosovicka conducted research on the use of SE with specific condensing burs for lateralization and compaction of bone while simultaneously inserting dental implants [10]. SE has the potential to accomplish a wide range of objectives, including simultaneous implant insertion, reduced treatment time, and the elimination of the need for bone grafting [12]. When placing implants in patients with jaw bone resorption, nontraumatic bone expansion with screws of increasing diameter is a straightforward and effective procedure [13].

Huwais [14] was the first who proposed the OD technique, which involves utilizing burs that assist in densifying bone while creating an osteotomy, widening narrow alveolar ridges without dehiscence or fenestration, permitting simultaneous installation of dental implants, and lifting maxillary sinus floor without perforation [15, 16]. These burs have the same benefits as drills and osteotomes in terms of increased speed and tactile sensitivity with minimal heat generation, which help in the preservation of healthy bone and improvement of implant osseointegration [17]. The use of OD in implant site preparation effectively increases the size of the alveolar bone, which in turn can be used instead of bone grafts in augmentation surgery [18]. OD improves ridge thickness because of bone expansion and few buccal bone defects following implant placement [11]; a high degree of expansion is observed at the crest in thin ridges with sufficient trabecular bone volume [19].

Studies that compare OD and SE techniques in terms of bone width gain and operating time are limited. Therefore, this study aimed to compare OD and SE techniques with regard to bone width gain and operating time to determine which method is better. The hypothesis was that OD would accomplish equal ridge expansion compared with manual screw expander drills.

Materials and methods

The research was conducted at the Implantology Unit/Department of Oral and Maxillofacial Surgery, Dental College Teaching Hospital, University of Baghdad, Iraq, from December 2021 to July 2022. Inclusion criteria included patients aged ≥18 years without any systemic disease and local pathological lesion and with fair-to-good oral hygiene and healed planned implant insertion sites at least 6 months after tooth extraction. A ≥2 mm trabecular bone core and trabecular/cortical bone ratio ≥1/1 were needed to achieve a predictable plastic bone expansion. Exclusion criteria included medically compromised patients; jaw regions with high bone densities (D1 and D2) according to Misch bone classification based on

cone beam computed tomography (CBCT) findings [20]; parafunctional habits, such as severe bruxism and clenching; heavy smoking (>20 cigarettes daily); and alcohol abuse.

Detailed previous medical and dental histories were obtained from every patient by special forms of case sheets. A CBCT was obtained for each patient to measure alveolar ridge width and height. The study received approval from the institutional research ethics committee (reference number 410121), and all patients provided informed consent prior to the initiation of treatment.

Study design and sample preparation

In the present study, 19 patients received 40 implants. Fifteen implant osteotomies were accomplished for seven males, and 25 osteotomies for 12 females. A random allocation sequence for the groups was created using GraphPad Prism 9 software. The list of randomized sequences and the timing of enrolment were used to divide the patients into two groups. The whole sample was divided into SE group, which consisted of 20 implant sites after alveolar bone expansion with threaded screw expander drills (ORANGE, Houston, Texas, USA), and the OD group, which consisted of 20 implant sites after alveolar bone expansion utilizing Densah burs (Versah Co, Jackson, Mississippi, USA).

Surgical procedure

Preoperative antibiotics composed of 1000 mg of amoxicillin + clavulanate potassium or 600 mg clindamycin capsule was prescribed to each patient one hour before surgery to prevent suspected post-operative infection [21,22]. Before surgery, the patients were instructed to gargle 0.12% chlorhexidine mouthwash for about a minute. Then, a gauze soaked in povidone–iodine solution was used to scrub the perioral area.

All procedures were performed after administering local anesthesia via buccal and lingual infiltration of lidocaine hydrochloride (2%) with epinephrine (1:80,000) at the intended surgical site. A three-sided mucoperiosteal flap was reflected.

Exposed alveolar ridge and the crest width was measured before implant site preparation. A bone caliper was applied to the exposed alveolar ridge 1 mm below the crest, and the value was recorded, as illustrated in Figure 1.

Figure 1: Alveolar ridge width measurement before implant site preparation.

SE group: A pilot drill of the ORANGE bone expanders kit with a 2 mm diameter and an angled handpiece rotating at 800 rpm was used. After the required length was achieved with the pilot drill, the first screw expander, a manual expander with a 2.5 mm diameter, was used with the ratchet included in the kit. Every

two turns, a 20–30-second pause was required to enable the bone to adapt to the applied stress and expand in a controlled manner. To prevent hesitant expansion that can compromise the cortical plate, the screw expander was rotated counterclockwise upon encountering significant resistance, removed for 20 seconds, and then reinserted under saline irrigation. The first expander remained in position for approximately one minute after reaching the desired length. The expander was removed, and the next one was placed in the same manner until the desired diameter was reached, accommodating a dental implant of the required dimensions, as indicated in Figure 2.

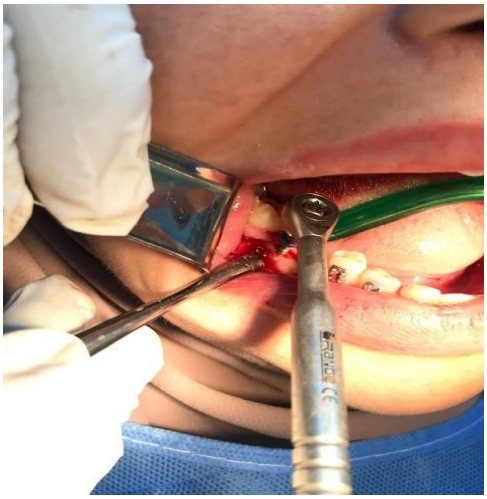

Figure 2: Bone expander used manually in sequential manner.

OD group: A pilot Densah® drill (1.7 mm) was inserted into the desired depth in a clockwise drill speed of 800 rpm with copious normal saline irrigation. According to the instruction for ridge expansion provided by Versah, the implant diameter was selected to be the same as or slightly larger than the initial ridge width (up to 0.7 mm larger) according to CBCT and confirmed by clinical measurement after flap reflection. Implant site preparation with Denash burs was carried out in counterclockwise densifying mode via sequential incremental drilling (counterclockwise drill speed 800 rpm) with copious normal saline irrigation, as illustrated in Figure 3. The final drill diameter was 0.1–0.2 mm less than the implant diameter.

Figure 3: Drilling with Densah burs in counter clockwise rotation.

After implant site preparation, alveolar ridge width was measured 1 mm below the crest for each group to determine the degree of ridge expansion. Time was measured with a digital stopwatch from the first perforation of the cortical bone with a pilot drill until the implant with a 3.5 mm diameter was finally inserted. Time measurements were recorded in minutes. Measured times included the time required to change the drills and time needed to remove the drill from the osteotomy site for each implant site. The drilling protocol required for implant site preparation (e.g., 3.5 mm diameter) was performed according

to the suggestions of the manufacturer. However, it was not equal in the two surgical kits. For the SE kit, only four drills were used, whereas for the OD kit, four to six drills were needed to prepare the site.

Statistical analysis

Statistical analysis was performed using GraphPad Prism. Descriptive statistical analysis included calculation of mean, standard deviation, and confidence interval (mean 95% CI). Unpaired t-test was used to estimate differences in alveolar ridge width before preparation and the amount of width gain between the groups. Paired t-test was used to assess difference between ridge width before preparation and ridge width after preparation according to the expansion technique. Unpaired t-test was used to assess the statistical significance of the operating time for both groups.

Results

A total of 19 patients, 12 females and 7 males, with an age range of 22–59 and a mean ± standard deviation age of 45.37 ± 11 participated in this study. Before the expansion, the mean alveolar ridge width was 4.20 ± 0.71 mm (OD) and 4.52 ± 0.53 mm (SE). No statistically significant difference in alveolar bone width before expansion was found between the two groups (P > 0.05). A nonsignificant difference in the preoperative bone density of the proposed implant site was found between the groups (P = 0.932), and the means of the SE and OD groups preoperative bone density were 435.2 ± 174.4 and 430.3 ± 148 HU, respectively. After the expansion of the alveolar ridge with OD or SE, the average ridge width at 1 mm below the crest was 5.48 ± 0.57 mm (OD) and 5.71 ± 0.53 mm (SE). The difference between the preoperative alveolar ridge width and postoperative alveolar ridge width was statistically significant for both groups (P < 0.05), as shown in Table 1.

Table 1: Difference between the preoperative and postoperative of the residual alveolar ridge width.

Technique	Ridge width	Mean ± SD (mm)	P-value (0.05)
OD	Ridge width preoperatively	4.20 ± 0.71	<0.0001* [S]
	Ridge width postoperatively	5.48 ± 0.57	
SE	Ridge width preoperatively	4.52 ± 0.53	<0.0001* [S]
	Ridge width postoperatively	5.71 ± 0.53	

OD = Osseodensification, SE = Screw expander, * = paired t test, S = Significant

The mean ± standard deviation width gain at 1 mm below the alveolar ridge crest was 1.28 ± 0.64 mm for the OD group and 1.19 ± 0.56 mm for the SE group. The difference in width gain between the groups was not statistically significant (P > 0.05), as shown in Table (2).

Table 2: Alveolar ridge width preoperatively and width gain postoperatively in osseodensification and screw expansion groups.

Group	Alveolar ridge width preoperatively (mm)	Alveolar ridge width postoperatively (mm)	Width gain (mm)
OD	4.20 ± 0.71	5.48 ± 0.57	1.28 ± 0.64
SE	4.52 ± 0.53	5.71 ± 0.53	1.19 ± 0.56
			P = 0.414*
Total	4.36 ± 0.62	5.59 ± 0.55	1.23 ± 0.60

OD = Osseodensification, SE = Screw expanders, * = Unpaired t test.

According to the duration of operating time, there was a high significant difference in operation time consuming between the SE and OD groups (P < 0.0001) for a single implant. The mean time consumed by OD was 6.21 ± 0.55 min, and the mean of operating time by SE was 16.32 ± 0.60 min, as shown in Table (3).

Table 3: Time of surgical operation for osseodensification and screw expansion.

	Surgical time (minutes)			
Group	Mean	SD	95% CI	P-value
OD	6.21	0.55		
			−10.48 to −9.73	<0.0001*
SE	16.32	0.60		

OD = Osseodensification, SE = Screw expanders, * = Unpaired t test.

Discussion

In this study, SE and OD resulted in the efficient expansion of narrow alveolar ridges with adequate trabecular bone and low density (D3 and D4) and simultaneous implant placement. The mean bone width gained by SE was 1.19 mm; this technique significantly increased the width of the alveolar crest from about 4.52 mm to 5.71 mm during implant site preparation; this result was consistent with the results of most studies on the use of SE. Cortes and Cortes gained 2.5 mm in ridge width after treating 21 patients with bone screws and immediate implant placement; they reported that atraumatic bone expansion with screws of increasing diameter can be used as a straightforward and practical procedure to insert implants for cases with jawbone resorption [13]. Mazzocco et al. reported that 1.5 mm horizontal bone gain was measured on an axial computed tomography at 2 mm below the crest when they used motorized screw expanders in narrow alveolar ridge with a bone crest thickness between 3 and 5 mm [23]. Furthermore, Chan et al. observed a mean width gain of 2 mm at the occlusal point and 0.79 mm apical to the crest after the restoration of 11 maxillae with 20 implants placed simultaneously with the expander technique [24]. Moreover, in a related clinical study, M Abdulrahman and A Hassan observed a significant bone width gain with the use of screw expanders; the mean bone gain was 1.79 mm [25].

In the OD group; the average amount of bone width gained by OD was 1.28 mm (1 mm below the crest). It significantly increased the width of the alveolar crest from about 4.20 mm to 5.48 mm during implant site preparation without causing dehiscence or fenestration in the alveolar bone. This result was in line with the results of most studies that utilized the OD technique. After placing 20 implants in the iliac crests of two animals, Trisi et al. observed a 30% expansion in the width of the iliac ridge and an increase in the percentage of bone volume as compared with those observed after standard drilling [26]. Gaspar et al. used OD for implant site preparation in maxillary alveolar ridges with decreased width ranging from 3.2 mm to 5.1 mm, which was consistent with the findings of the current study; according to the findings, the expansion amount varied between 1.1 and 2.4 mm, and thin ridges showed a higher degree of expansion than thicker ones [27]. Yeh et al. reported significant bone width gain at 1 mm below the crest after expansion with OD, and the mean width gain was 0.75 ± 0.22 mm [28]. Furthermore, Salman and Bede concluded that OD permits the expansion of alveolar ridges; they stated that the mean coronal width significantly increased from 4 mm to 5.3 mm after utilizing the OD, and the mean expansion was 1.29 mm; these findings concur with the findings of the conducted study [15]. The difference in average width gain among

studies can be due to a number of variables, such as the point at which the width was measured, the bone density, the jaw included in the study, and the method used in measuring width.

In the present study, increase in alveolar ridge thickness after site preparation was significant in each group. The difference in width gain after ridge expansion by SE or OD was not statistically significant (P = 0.414). These findings coincided indirectly with those of other studies. Kao and Fiorellini compared ridge expansion by screw expanders with ridge splitting on swine cadavers; they observed no statistically significant difference between the two methods in terms of crestal width gain. The average crestal width gain with screw expanders was 1.92 ± 0.61 mm [29]. Tian et al. compared OD and conventional osteotome technique in porcine models with a horizontally atrophic ridge; they reported no statistically significant difference in the degree of ridge expansion between two groups [30]. By contrast, this study was inconsistent with a study published by Abdel-Rahman et al., who observed that OD produced significant expansion at the occlusal level in comparison with the conventional expander technique; the mean bone width gain was 1.86 and 1.03 mm, respectively [31].

According to operating time, the mean operating times of SE and OD were 16.32 and 6.21 minutes. SE consumed much more time than the OD technique (P = 0.0001) because each screw expander is left in place for one minute when it reaches the desired length; it is also unhandled for 20–30 seconds when resistance is encountered in each half twist. In an ex vivo study, Bhargava et al. observed that the OD technique takes less surgical operation time than using compressive osteotomes and piezoelectric devices [32]. The duration of the drilling procedure showed a direct correlation with the amount of frictional heat generated. Eriksson and Albrektsson [33] indicated that subjecting bone to a temperature of 47 °C for 5 minutes results in a significant level of bone resorption (approximately 20%) over a 30-day period. This effect was associated with the infiltration of fat cells and limited osteogenic activity. A short operating time may be beneficial to reducing fear and anxiety among patients [34, 35].

Conclusion

The main limitation of this study is its small sample size. The OD technique is comparable to the SE technique according to the results of ridge width gain assessment. The former requires less operating time than the latter.

Conflict of interest

The authors have no conflicts of interest to declare.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Nawfal Hasan Tofan] and [Ali H. Abbas Al-Hussaini]. The first draft of the manuscript was written by [Nawfal Hasan Tofan] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Informed consent

Informed consent was obtained from all individuals or their guardians included in this study.

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كفاءة التكثيف العظمي مقابل تقنية التوسيع اللولبي لتوسيع العظام السنخية الضيقة: دراسة مقارنة سريرية

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المستخلص:

يقترح توسيع العظام السنخية عندما يكون سمك القمة السنخية اقل من 5 مم. تم استخدام تقنية التوسيع اللولبي لسنوات عديدة لتوسيع العظام السنخية الضيقة. في الآونة الأخيرة ، تم اقتراح تقنية التكثيف العظمي كتقنية موثوقة لتوسيع العظام السنخية الضيقة مع كسب عرض فعال وأقل وقت ممكن من العمل الجراحي. تهدف الدراسة الحالية إلى مقارنة التكثيف العظمي و اللوالب من حيث كسب العرض السريري ووقت العمل. الطرق والمواد: تم إجراء أربعين عملية قطع عظم في العظام السنخية الأفقية الناقصة (3-5 مم). تم اختيار مجموعه 19 مريضا تتراوح أعمارهم بين 21 و 59 عاما بشكل عشوائي إلى مجموعتين: مجموعة التوسيع اللولبي ، والتي تضمنت 20 عملية قطع عظم تم إجراؤها بواسطة الموسعات اللولبيز ومجموعة التكثيف العظمي: والتي تضمنت 20 عملية قطع عظمي الحفر العظمي. تم القياس ملمتر واحد تحت قمة العظم السنخي بمعيار عظمي على فترتين (قبل قطع العظم وبعد قطع العظم) ، وتم تقييم وقت العمل الجراحي. النتائج: قبل التوسيع كان متوسط عرض التلال السنخية 4.20 ± 0.71 ملم في مجموعة التحسس العظمي و4.52 ± 0.53 ملم في مجموعة التمدد اللولبي. لم يكن هناك فرق ذو دلالة إحصائية في عرض العظم السنخي قبل التوسع بين المجموعتين ($p > 0.005$). بعد توسيع العظام السنخية باستخدام تقنيات التكثيف العظمي أو اللولبي ، كان متوسط عرض التلال 5.48 ± 0.57 مم في مجموعة التكثيف العظمي و 5.71 ± 0.53 مم في مجموعة التوسيع اللولبي. كان الفرق في مكاسب العرض بعد الجراحة بين المجموعتين 0.09 مم ، وهو أمر غير ذي دلالة إحصائية ($p > 0.005$). الاستنتاج: أظهر توسع العظم السنخي عن طريق التكثيف العظمي زيادة عرض متوافقة ووقت عمل جراحي أقل مقارنة بالتوسيع بواسطة تقنية التوسيع اللولبي.