

# EVALUATION OF BONE AUGMENTATION USING AUTOLOGOUS TOOTH SHELL IN THE ESTHETIC ZONE OF NARROW MAXILLA (A CLINICAL STUDY)

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## ABSTRACT

**INTRODUCTION:** Following extraction of tooth, the alveolar bone is resorbed in different directions with variant measurements. The decrease in alveolar bone width is higher in amount than alveolar bone height resorption, and is most significant buccally. The autologous tooth shell (ATS) had been of great interest in dental research as for its low cost and less aggressiveness than Autogenous bone (AB), also it showed similar composition to bone tissue. Furthermore, ATS proved to have osteogenic and osteoconductive characteristics as AB.

**MATERIALS AND METHODS:** A prospective clinical trial was carried on 12 patients of both sexes between the ages of 20-45 years. Patients who were radiologically diagnosed with narrow maxillary ridge in the anterior and/or premolar area. Tooth shells were used to augment the narrow ridge, by fixing them buccally with osteosynthesis screws.

Cerabone® bone granules and a resorbable collagen membrane were used. Measurement of horizontal ridge width (HRW) was done both preoperatively (HRW1) and 4 months postoperatively (HRW2) using CBCT. Participant patients were fully informed of the clinical trial and had to sign a written informed consent.

**RESULTS:** The age of the selected sample size varied from 20 to 45 years old, with a mean of  $42.08 \pm 2.19$ , and there were three men and nine females. 10 cases underwent uneventful recovery showing no signs of infection while 2 cases showed dehiscence. ATS persisted and united to the narrow ridge four months after surgery. ATS was utilized in the augmentation of the narrow ridge, from a narrow ridge width HRW1 of mean value  $4.46 \pm 0.51$  mm to the final HRW2 of mean value  $6.85 \pm 0.63$  mm after 4 months of surgery. The average horizontal ridge width gain HRWG was  $2.40 \pm 0.41$  mm. Cancellous bone density of augmented maxillary ridge showed minimal or no significant change 4 months post operatively.

**CONCLUSION:** This study showed that autologous tooth shell improves esthetics and bone healing and bone thickness in the esthetic zone of maxilla. ATS is a potential replacement for traditional autologous bone grafts in the future.

**KEYWORDS:** Autologous tooth shell, Esthetic zone, Maxilla, Bone deficiency, Clinical study

**RUNNING TITLE:** Bone augmentation using autologous tooth shell.

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## INTRODUCTION

During clinical treatments, several alveolar bone abnormalities are observed. Twelve weeks following extracting a tooth, the alveolar bone width is reduced by 32% (1). When the buccal bone width measurement is below 1 mm., significant reduction in alveolar bone height (about 7.5 mm) happens within two months. Defects that are horizontal, vertical, or mixed have a major impact on restoring the extracted tooth and ultimate aesthetics. Autogenous bone (AB) is considered the best bone grafting material in the treatment of narrow alveolar ridge due to its osteogenic property (2,3). However, AB has disadvantages that cannot be avoided, including scarring of the area where

bone blocks are taken, a decreased blood supply in that area, as well as unwanted absorption (4).

Alternative bone transplants with diverse origins are therefore being used. They have numerous sources and can shorten operating times with low morbidity of donor site (5). As a result, ongoing researches in order to create a more suitable grafting bone material are done (6). Due to being less expensive and less invasiveness than AB and having components that are similar to bone tissue, tooth shell of autogenous origin has recently received a lot of interest (7). In addition, TS shares the same osteogenic and osteoconductive qualities as AB. It demonstrates that dentin has growth factors associated to osteogenesis that are widely

dispersed in the extracellular matrix (ECM) (8). These osteogenic factors include transforming growth factors (TGF-), which stimulates the proliferation and development of osteoblasts, and bone morphogenetic proteins (BMPs), driving mesenchymal stem cells to differentiate into osteoblasts therefore promote bone production (9). Within a few weeks of a maxillary anterior tooth being lost, there is a large loss of buccal bone, which causes a depressed bone shape, a lack of keratinized gingiva, and aesthetic problems. Due to few scientific research that supports ATS as a potential autogenous augmentation to the maxillary narrow ridge in the anterior and/or premolar area, this study was therefore aimed to do research on the therapeutic efficacy of bone augmentation with tooth shell in the aesthetic zone of narrow maxilla using radiographic evaluation before and after 4 months of bone augmentation, which will provide more scientific support for TS as a potential replacement for common autologous grafts used for augmentation of bone (10).

## MATERIAL AND METHOD

### Study setting and location

This study was approved by the Committee of Ethics of Faculty of Dentistry of Alexandria University on year 2022 (IRB NO: 00010556\_IORG 0008839). Twelve patients with narrow residual ridge in maxillary esthetic zone were chosen from the Outpatient Clinics of the Faculty of Dentistry Alexandria University's Department of Oral and Maxillofacial Surgery. All patients in the study sample had to sign an informed consent preoperatively.

### Study sample calculation

The minimal sample size was calculated based on a previous study aimed to estimate the outcome and follow up of autologous tooth shell (ATS) grafting technique for bone augmentation in the esthetic zone. Li S et al., (2021) concluded that ATS grafting is a good technique for bone augmentation in the esthetic zone. (11)Based on their results, and adopting a power of 80% to detect a standardized effect size ( $d$ ) = 0.862 (large sized standardized effect size) in the horizontal ridge width (primary outcome) at a 4 months postoperative, and level of significance 5% ( $\alpha$  error accepted= 0.05), the minimum required sample size was found to be 10 patients.(12) Anticipated dropout rate is 20% so, sample size was increased to 12 patients to control for any withdrawal.(13)

### Inclusion criteria

The age range of the study sample was (20-45) year old of males and females. Selected patients had one extracted tooth or more in the maxillary esthetic zone and a badly decayed or impacted molar tooth. The narrow maxillary alveolar ridge mean width range was from 3-5 mm when measured by preoperative CBCT radiograph (14).

### Exclusion criteria

Including any chronic disease which may make surgery of bad prognosis, like uncontrolled diabetes mellitus, bone porosity and patients receiving radiotherapy. Pregnant and lactating females. And heavy smokers. In addition to bruxism or clenching as it will affect the cortical bone thickness of the augmented maxillary ridge (15).

### Materials

1. Devedmed screws of 1.5 width and length of 9 mm were used (Manufactured by Devedmed, Germany)
2. Cerabone ® 1 ml (manufactured by Botiss dental, Germany)
3. Resodont collagen membrane of dimensions 16x25mm (manufactured by Dantaurum, Germany)

### Methods

#### Pre-operative assessment

##### 1- History

###### a) Personal data

Documented full name, birth date, gender, occupation and contact numbers were obtained in the patient's sheet.

###### b) Past medical history

Documented medical history for any previous surgeries, any systemic condition, allergies and medications.

###### c) Past dental history

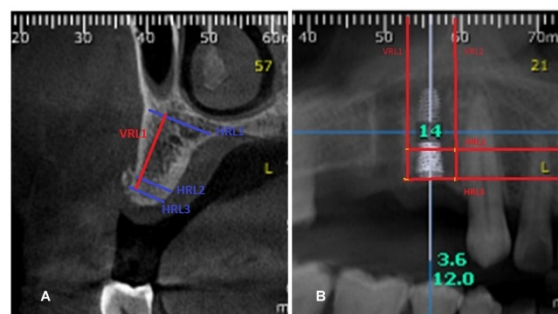
Documented data about any previous dental visits and asked questions about how and when were the teeth lost.

##### 2- Clinical examination

All patients were examined extra-orally for any lymph node or temporo- mandibular joint abnormalities by palpation and were examined intra-orally for any lesions or bone abnormalities by inspection and palpation.

##### 3- Radiographic examination

The bone width preoperatively (HRW1) and the bone density (D1) of the narrow maxillary ridge were measured using a cone beam computed tomography (CBCT). A mean value was calculated based on readings at 4 points at the most concave part of the residual ridge to be augmented (Figure1).



**Figure 1:** Pre-operative CBCT radiograph (A): (sagittal view showing ): A reference tracing line was drawn at the lowest point between the

maxillary sinus and the anterior nasal spine horizontally (HRL1). Another 2 horizontal reference (HRL2) and (HRL3) lines were drawn 3 mm apart sub crestally and parallel to each other at the site of augmentation. **(B) (panoramic view showing)** using the 90° angle tool, 2 vertical reference lines (VRL1) and (VRL2) were drawn parallel to each other and perpendicular on the horizontal reference lines apically and sub crestally intersecting (HRL2) and (HRL3) at 4 points in which the average reading for the 4 points was calculated in order to reach the mean values to be measured at the augmented ridge site.

### I. Operative phase (Figures 2 and 3 )

Under aseptic conditions, the patient received local anesthesia (Articaine hydrochloride 4 percent; Epinephrine, 1:100,000) (Artpharma, Egypt). The wisdom tooth or badly decayed tooth was gently extracted and pulp removal was done using a nerve proach. Then thoroughly rinsed with phosphate buffer saline PBS without calcium or magnesium (Biowest, USA) + 2% penicillin/streptomycin (Biowest, USA) +1% closol antifungal (European Egyptian pharmaceutical industries, Egypt). (A solution of 100 ml was prepared in the clinic consisting of 90ml of buffer saline and 10 ml of 2% penicillin/streptomycin +1% antifungal) and the extracted tooth was kept in it for 15 minutes (Figure2A). The tooth was cleaned from any debris and then the enamel and cementum part of the tooth was removed by a coarse diamond bur under sterile saline (0.9%) cooling. After that, the tooth was cut in a longitudinal direction using a diamond disk (Figure2B). The tooth shell (TS) (thickness of 1–1.5 mm) was prepared to a desired contour and according to the bone defect concavity in the narrow ridge. This was designed to be adapted to buccal concavities of the narrow maxillary ridge. Then, the ATS were predrilled (Figure2C). One mid crestal incision and 2 vertical incisions were done using blade 15. Full thickness mucoperiosteal flap retraction using a periosteal elevator was done at the position of narrowed maxillary ridge to allow for ATS fixation (Figure 2D).

Later, the obtained ATS was rigidly fixed to the narrow maxillary ridge by one or more osteosynthesis screws (1.5 × 9 mm) (Devemed, Germany) (Figure 2E). Bone granules were used at the augmented site Cerabone® 1 ml\* to act as a filling between the fixed ATS and the augmented ridge. Which then were covered by a resorbable collagen membrane to ensure complete healing (Figure2F). Finally, fenestrations along the periosteum of buccal flap was performed using a scalpel for wound closure without tension (Figure2G).

Four months postoperatively, all of the patients undergone another surgery to remove osteosynthesis screws. (Figure3)

## II. Post-operative phase

### A. Post-operative care

All patients were given antibiotics every 12 hours for 7 days (amoxicillin +clavulanic acid 1gm) (Emoxclav: Amoxicillin 875 mg + Clavulanic acid 125 mg: EPICO, Egypt) and were instructed to follow a strict oral hygiene measures and rinsed regularly with Betadine mouthwash two times a day for a period of 7 days (Betadine: povidone iodine 1%, Arabic drug company mundipharma). Non steroidal anti inflammatory drug was prescribed every 8 hours for 5 days (Cataflam: Diclofenac Potassium 50mg: Novartis- Switzerland). Patients were advised to apply cold packs extra orally at the site of surgery just following the end of the operation for 15 minute each time and for the rest of the day every two hours in order to control post operative pain, followed by warm packs on the following day to enhance wound healing (16).

### B. Post-operative follow up

#### a. Clinical follow-up phase

On the second and fifth day of surgery, the suture wound was examined for any signs and symptoms of inflammation including, redness, hotness. Then Sutures were removed after 10 days postoperatively.

Uneventful healing was noted during the postoperative clinical follow-up for all cases, except for two cases, where there was bone graft exposure at the 10<sup>th</sup> postoperative day. The two cases needed further intervention so flap reflection and suturing without tension 10 days post operatively was done but with healthier mucosa. These patients were instructed to follow a strict oral hygiene measures and mouth wash (Betadine mouth wash). Anti-inflammatory medication (Cataflam) was prescribed twice daily for the following 5 days and regular cold fomentation to control post operative pain for the first 24 hour after wound suturing. The 2 cases showed uneventful healing and no signs of infection 10 days later.

Post operative pain measurements were calculated in VAS scale from 1 to 10 according to patients clinical follow up on the 2nd, 5<sup>th</sup> and 10<sup>th</sup> day.

#### b. Radiographic evaluation phase

Four months postoperatively, another CBCT was done in which a reference tracing line was drawn at the lowest point between the maxillary sinus and the anterior nasal spine horizontally (HRL1). Another 2 horizontal reference (HRL2) and (HRL3) lines were drawn 3 mm apart sub crestally and parallel to each other at the site of augmentation. By using the 90° angle tool, 2 vertical reference lines(VRL1) and (VRL2) were drawn parallel to each other and perpendicular on the horizontal reference lines apically and sub crestally intersecting (HRL2) and (HRL3) at 4 points in which the average reading for the 4 points was calculated in order to reach the mean values to be measured at the augmented ridge site.

HRW2 mean values were calculated for the 12 patients at the augmented ridge site. The final horizontal bone width gain (HRWG) was determined using the formula (HRW2 – HRW1) (Table 1).

Based on CBCT-data, bone density was assessed prior to surgery and four months afterwards. Bone density (BD) of cancellous bone was measured by calculating the mean value of readings at the same exact points marked on the CBCT and compared to the preoperative bone density. (Table 2)

The radiograph had been performed with field of view (FOV) W 100mm x H 50mm with 0.160mm isometric voxel size. The tube voltage was 90KV (kilovoltage), 8 mA (Milliampere), and the exposure time was 20 seconds. The CBCT radiographic machine was set to have same specifications (before and after 4 months following the procedure). All CBCT radiographs had been performed with the same radiographic machine for the accuracy(17).

**RESULTS**

Twelve patients were included in the trial, three men and nine females and treated at Alexandria University's Faculty of Dentistry's Department of Oral and Maxillofacial Surgery. The age of the patients varied from 20 to 45 years, with a mean of 42 years. IBM® SPSS® Statistical software version 22.0 was used to analyze the collected data to reach the following results(18)

**A. Clinical follow up**

10 cases underwent uneventful recovery showing no signs of infection while 2 cases showed dehiscence. ATS persisted and united to the narrow ridge four months after surgery.

Post operative pain intensity measured by VAS score decreased significantly after the 7<sup>th</sup> day postoperatively with a mean value of 5.40 ± 0.84 and P value less than 0.001.(Table1)

**B. Radiographic follow up (Figures 4 and 5)**

Preoperatively, the HRW1 mean value was 4.46±0.51 mm. After 4 months postoperatively HRW2 mean value was 6.85±0.63mm with a statistically significant difference ( P-value < .01). The average horizontal ridge width gain HRWG was 2.40±0.41 mm. (Table2) Cancellous bone density of augmented maxillary ridge showed no significant change 4 months post operatively ( P-value > 0.05 ). (Table3)

**Table 1:** Mean value pain intensity of the patients post operatively measured by VAS score.

| Day of measurement                    | 5 <sup>th</sup> day postoperatively | 7 <sup>th</sup> day postoperatively |
|---------------------------------------|-------------------------------------|-------------------------------------|
| Pain Intensity (VAS score) mean value | 6.98 ±0.89                          | 5.40 ± 0.84                         |

P-value < .001\*

\*Statistically significant

**Table 2:** Mean values of the Horizontal Ridge Width preoperatively HRW1 and 4 months postoperatively HRW2 and HRWG calculated by the equation HRW2-HRW1.

|   |   |
|---|---|
| <b>Horizontal Ridge Width (HRW1) (mm)</b>                   |   |
| <b>Preoperative</b>   |   |
| - n   | 12                                      |
| - Min-Max   | 3.37-5.00                               |
| - Mean ± SD   | 4.46±0.51                               |
| - SE of Mean  | 0.11                                    |
| - 95.0% CI of the mean                                      | 4.22-4.69                               |
| - 25 <sup>th</sup> Percentile – 75 <sup>th</sup> Percentile | 4.17-4.96                               |
| - Interquartile Range                                       | 0.81                                    |
| - Kolmogorov-Smirnov test of normality                      | D=0.197, p=0.77 NS                      |
| <b>Four months Postoperative (HRW2)</b>                     |   |
| - n   | 12                                      |
| - Min-Max   | 5.60-8.00                               |
| - Mean ± SD   | 6.85±0.63                               |
| - SE of Mean  | 0.14                                    |
| - 95.0% CI of the mean                                      | 6.57-7.14                               |
| - 25 <sup>th</sup> Percentile – 75 <sup>th</sup> Percentile | 6.50-7.20                               |
| - Interquartile Range                                       | 0.83                                    |
| - Kolmogorov-Smirnov test of normality                      | D=0.118, p=2.00 NS                      |
| <b>Paired t test of significance p-value</b>                | t <sub>(df=20)</sub> =26.821<br>p<0.01* |
| <b>HRW percentage change (%)</b>                            |   |
| - n   | 12                                      |
| - Min-Max   | 40.00-74.18                             |
| - Mean ± SD   | 54.58±11.99                             |
| - SE of Mean  | 2.62                                    |
| - 95.0% CI of the mean                                      | 49.13-60.04                             |
| - 25 <sup>th</sup> Percentile – 75 <sup>th</sup> Percentile | 44.44-65.79                             |
| <b>Horizontal Ridge Width Gain (HRWG)(mm)</b>               |   |
| - n   | 12                                      |
| - Min-Max   | 1.60-3.20                               |
| - Mean±SD   | 2.40±0.41                               |
| - SE of Mean  | 0.09                                    |
| - 95.0% CI of the mean                                      | 2.21-2.58                               |
| - 25 <sup>th</sup> Percentile – 75 <sup>th</sup> Percentile | 2.00-2.50                               |

n: number of patients

Min-Max: Minimum to Maximum

SD: Standard deviation

SE: Standard error

CI: Confidence interval

t: Independent Sample t test

W: Welch's correction

p<sup>2</sup>: Pearson Chi-Square

df: degree of freedom

NS: Statistically not significant (p≥.05)

\*: Statistically significant (p<.05)

**Table 3:** Comparison of the bone density preoperatively and after 4 months (n=12). Measured on CBCT scan by Hounsfield Scale (HS).

| Preoperative bone density (BD) (HU)                                      | 4 months post operative bone density (BD) (HU)                             |
|--|--|
| n=12<br>min. -max.= 210 - 560 HU the mean=400 HU<br>P value= 0.326<br>NS | n=12<br>min. -max.= 209 - 500 HU the mean=399.4 HU<br>P value= 0.253<br>NS |

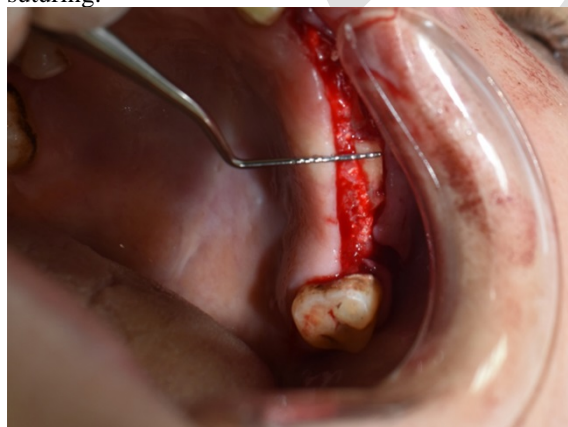
n: number of patients

min-max: minimum – maximum

NS: statistically nonsignificant (P-value > 0.05)

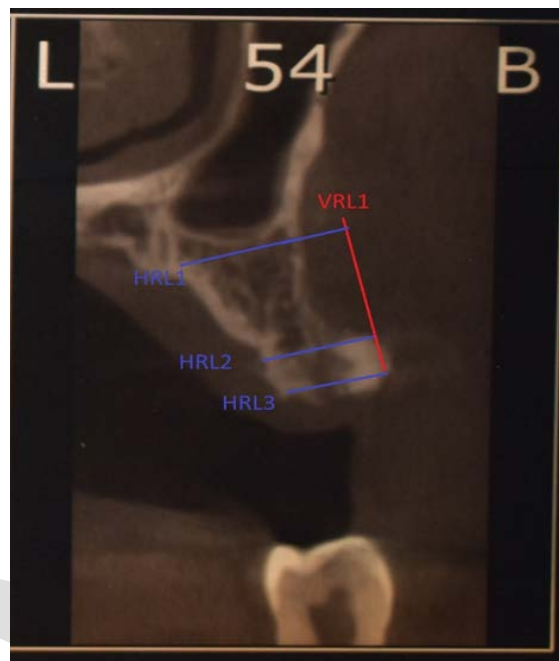


**Figure 2:** (2A-F): preparation and fixation of autologous tooth shell. (A) soaking of extracted tooth in disinfection solution (B) tooth separated longitudinally by a diamond disk (C) TS grafts were predrilled (D) incision and flap retraction. (E) tooth shell rigidly fixed to bone using osteosynthesis screws. (F) bone granules and collagen membrane applied. (G) wound closure by suturing.

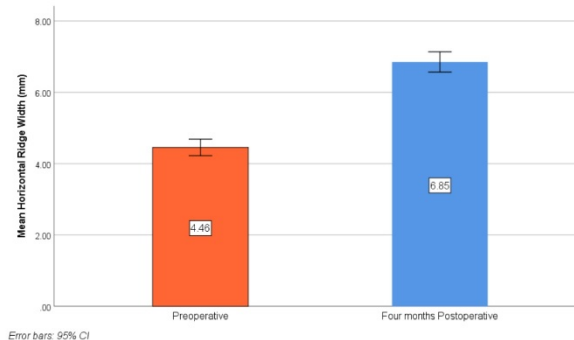


**Figure 3:** 4 months postoperatively osteosynthesis screws removed.

Successful augmentation by Autologous Tooth Shell (ATS) and Horizontal Ridge Gain (HRG) is evident clinically by using a periodontal probe.



**Figure 4:** 4- months postoperative CBCT scan (sagittal view) showing the augmented ridge area. A reference tracing line was drawn at the lowest point between the maxillary sinus and the anterior nasal spine horizontally (HRL1), Another 2 horizontal reference lines (HRL2) and (HRL3) were drawn 3 mm apart sub crestally and parallel to each other at the site of augmentation.



**Figure 5:** Histogram with distribution curve of mean horizontal ridge width of the studied group preoperatively and four months post operatively measured by CBCT radiographs.

**DISCUSSION**

In this study, in this clinical trial, the autologous tooth shell bone graft was evaluated for the enhancement of the narrow maxillary ridge at the anterior and /or premolar area at Alexandria University's Faculty of Dentistry's Department of Oral and Maxillofacial Surgery.

Similar to previous studies which stated that women care more about their beauty than men do. In fact, in this study it has been discovered that female patients

are more critical of and concerned with their dental appearance than male patients are (19).

In our study, it was found that the preparation process of ATS was not technique sensitive but rather time consuming, this agreed with the clinical study done by Shejali J, et al. in year 2020 (20).

Clinical follow up for all cases showed uneventful healing with no signs and symptoms of infection. Only 2 cases showed graft exposure ten days postoperatively, so further surgical procedure was performed, summarized in flap retraction, washing with saline and using blade number 15 to do fenestration of the periosteum of the retracted flap to gain more resilience to achieve flap closure with no tension. This resulted in uneventful successful healing results 10 days later. These findings agreed with the systemic review and meta-analysis of the clinical efficacy of autogenous dentin blocks prepared chairside for alveolar ridge augmentation done by Mahardawi, B, et al. in year 2023 which stated that in previous researched studies recorded incidences of graft exposure were low, and no study stated surgical site infection (21).

Our clinical follow up results showed that the postoperative pain decreased significantly after the 5<sup>th</sup> day postoperatively with a mean value of  $6.98 \pm 0.89$ . The highest value was found at the 7<sup>th</sup> day postoperatively with a mean value of  $5.40 \pm 0.84$ . This agreed with the clinical study performed by Belal Shehab et al. (22).

In this study, radiographic results showed a preoperative initial HRW1 of mean value  $4.46 \pm 0.51$  mm which significantly increased 4 months later to final HRW2 of mean value  $6.85 \pm 0.63$  mm which indicated HRWG of mean value  $2.40 \pm 0.41$  mm. These results were coherent and agreed to the systemic review done by Guan, Delin et al in year 2023 (23).

In this clinical trial the cancellous bone density of the augmented residual ridge and that of the autologous tooth graft showed nonsignificant change in bone density radiographically. This indicates that there was no or minimal resorption during the healing process. Which accordingly agrees with the findings of Daniel Buser et al in year 1996 in their clinical study augmentation of narrow ridge by the use of autografts and barrier membranes (24).

Our study results showed that the ATS presented a successful option for augmentation of alveolar bone. This was coherent with the retrospective observational study carried out by M Korsch in Germany in year 2019-2020. The results showed that ATS is a good alternative to autogenous bone grafting for the augmentation of alveolar ridge defects. It is a promising technique which prevents drawbacks of harvesting technique of autogenous bone (25).

In conclusion, this clinical trial proved that autologous tooth shell technique for ridge

augmentation is a promising technique due to its biological compatibility with the patient's bone. The clinical and radiographic follow up results indicated significant increase in bone width with no significant change in bone density. Though it is recommended to perform further histological studies on the junction between the patient's bone and the ATS in order to state clearly the nature of that dentoalveolar union. It is also advisable to perform a comparative clinical trial with a larger sample size, in order to prove the efficiency of ATS technique compared to other ridge augmentation techniques.

## CONCLUSION

This study showed that autologous tooth shell improves esthetics and bone healing and bone thickness in esthetic zone of maxilla. ATS is a potential replacement for traditional autologous bone grafts in the future.

### Conflict of interest

The authors state that they are not involved in any conflict of interest.

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## REFERENCES

1. Tan WL, Wong TL, Wong MC, Lang NP. A systematic review of post-extraction alveolar hard and soft tissue dimensional changes in humans. *Clin Oral Implants Res.* 2012;23:1-21.
2. Haugen HJ, Lyngstadaas SP, Rossi F, Perale G. Bone grafts: which is the ideal biomaterial? *J Clin Periodontol.* 2019;46:92-102.
3. Moussa NT, Dym H. Maxillofacial bone grafting materials. *Dent Clin.* 2020;64:473-90.
4. Hassan KS, Marei HF, Alagl AS. Does grafting of third molar extraction sockets enhance periodontal measures in 30- to 35-year-old patients? *J Oral Maxillofac Surg.* 2012;70:757-64.
5. Velázquez ÓI, Tresguerres FGF, Berrocal IL, Tresguerres IF, López-Pintor RM, Carballido J, et al. Split bone block technique: 4-month results of a randomised clinical trial comparing clinical and radiographic outcomes between autogenous and xenogeneic cortical plates. *Int J Oral Implantol (Berl).* 2021;14:41-52.
6. Zhang S, Li X, Qi Y, Ma X, Qiao S, Cai H, et al. Comparison of Autogenous Tooth Materials and Other Bone Grafts. *Tissue Eng Regen Med.* 2021;18:327-41.
7. Kim YK, Lee J, Um IW, Kim KW, Murata M, Akazawa T, et al. Tooth-derived bone graft material. *J Korean Assoc Oral Maxillofac Surg.* 2013;39:103-11.
8. Goldberg M, Kulkarni AB, Young M, Boskey A. Dentin: structure, composition and mineralization. *Front Biosci (Elite Ed).* 2011;3:711-35.

9. Baht GS, Hunter GK, Goldberg HA. Bone sialoprotein-collagen interaction promotes hydroxyapatite nucleation. *Matrix Biol.* 2008;27:600-8.
10. Becker K, Jandik K, Stauber M, Mihatovic I, Drescher D, Schwarz F. Microstructural volumetric analysis of lateral ridge augmentation using differently conditioned tooth roots. *Clin Oral Investig.* 2019; 23: 3063– 3071
11. Jun SH, Ahn JS, Lee JI, Ahn KJ, Yun PY, Kim YK. A prospective study on the effectiveness of newly developed autogenous tooth bone graft material for sinus bone graft procedure. *J Adv Prosthodont* 2014;6:528-38.
12. El Zahwy M, Taha SAAK, Mounir R, Mounir M. Assessment of vertical ridge augmentation and marginal bone loss using autogenous onlay vs inlay grafting techniques with simultaneous implant placement in the anterior maxillary esthetic zone: A randomized clinical trial. *Clin Implant Dent Relat Res* 2019;21:1140-7.
13. Chen ST, Darby I. The relationship between facial bone wall defects and dimensional alterations of the ridge following flapless tooth extraction in the anterior maxilla. *Clin Oral Implants Res* 2017;28:931-7.
14. Chappuis V, Engel O, Reyes M, Shahim K, Nolte LP, Buser D. Ridge alterations post-extraction in the esthetic zone: a 3D analysis with CBCT. *J Dent Res.* 2013;92:195S-201S.
15. Murray CE, Coleman CM. Impact of Diabetes Mellitus on Bone Health. *Int J Mol Sci.* 2019;20(19):4873. Published 2019 Sep 30. doi:10.3390/ijms20194873
16. Block JE. Cold and compression in the management of musculoskeletal injuries and orthopedic operative procedures: a narrative review. *Open Access J Sports Med.* 2010;1:105-13.
17. Faek AM, Samraa A, Elsheikh SA, Noueldin MG. Evaluation of one-Stage inverted U-Shaped ridge splitting and concurrent implant placement in anterior maxillary undercut defect (a Clinical Trial). *Alex Dent J.* 2023, 48: 28-34.
18. IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.
19. Vallittu PK, Vallittu AS, Lassila VP. Dental aesthetics--a survey of attitudes in different groups of patients. *J Dent.* 1996;24:335-8.
20. Shejali J, Thomas R, Kumar T, Shah R, Mehta DS, Gayathri GV. Immediate Ridge Augmentation Using Autogenous Tooth Root as a Block Graft in a Periodontally Hopeless Extraction Site: A Pilot Study. *J Oral Implantol.* 2020;46:41-49.
21. Mahardawi B, Kyaw TT, Mattheos N, Pimkhaokham A. The clinical efficacy for autogenous dentin blocks prepared chairside for alveolar ridge augmentation: A systematic review and meta-analysis. *Clin Oral Implants Res.* 2023;34:1025-37.
22. Belal SH, Khaled M, Atef M. Clinical and radiographic outcomes following lateral alveolar ridge augmentation using autogenous dentine block graft. *Al-Azhar JDS* 2023; 211:217.
23. Guan D, Zhao R, Guo Y, Li J, Ma N, Gong J. Efficacy of autogenous tooth block for lateral ridge augmentation compared with autogenous bone block: A systematic review and meta-analysis. *Medicine (Baltimore).* 2023;102:e35326.
24. Buser D, Dula K, Hirt HP, Schenk RK. Lateral ridge augmentation using autografts and barrier membranes: a clinical study with 40 partially edentulous patients. *J Oral Maxillofac Surg.* 1996;54:420-32.
25. Korsch M. Tooth shell technique: A proof of concept with the use of autogenous dentin block grafts. *Aust Dent J.* 2021;66:159-68.