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Autogenous dentin block versus bone block for horizontal alveolar ridge augmentation and staged implant placement: A randomized controlled clinical trial including histologic assessment

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Author Contributions

Leila Elraee: investigation (lead), methodology (equal), writing original draft (equal), data curation (equal). **Hala Kamal Abdel Jaber:** writing – review (lead), validation (equal), supervision (equal). **Hakem Hussein Elsayed:** writing original draft (equal), supervision (equal), validation (equal). **Doaa Adel-Khattab:** conceptualization (lead), formal analysis (equal), writing – review & editing (equal).

Running Title

Autogenous dentin block for horizontal alveolar ridge augmentation.

Abstract

Objectives: This study aimed to compare the dentin block (D-group) harvested from impacted wisdom teeth with autogenous ramus bone block (A-group) for horizontal alveolar ridge augmentation. **Materials and methods:** Forty two patients with anterior missing teeth and horizontal ridge defect were randomly assigned to two groups (n = 21 per group) to receive either dentin block group or autogenous bone block. Six months after the augmentation, dental implants were placed in all patients, and a core biopsy was performed for histological evaluation in addition to clinical and radiographic evaluation using cone beam computed tomography. Primary outcome was the mean overall clinical ridge width gain (CRWG) after 6 months of augmentation. Secondary outcomes were the overall radiographic ridge width gain (RRWG) after 6 months of augmentation and descriptive histological analysis with histomorphometric assessment of bone fraction %. **Results:** All sites healed uneventfully, and the mean overall CRWG 6 months after augmentation was 3.52 ± 0.56 mm and 2.24 ± 0.86 mm in the D and A groups, respectively, with statistically significant difference between them (*P* = < 0.001). The overall mean RRWG was 3.61 ± 0.61 mm and 3.41 ± 1.15 mm in D and A groups, respectively, without any statistically significant difference between them *(P* = 0.062) . The histomorphometric analysis of the bone area fraction was 42.6% and 41.3% in D and A groups, respectively, without any statistically significant difference between the two values (*P* = 0.89, Student's t-test). Histological evaluation in the D-group revealed new bone formation, viable cells, and matrix formation on the dentin block periphery, in addition to well-organized woven bone that suggests dentin block remodeling and supports new bone deposition. **Conclusion:** The present clinical study revealed that dentin block may serve as an alternative graft to support horizontal alveolar ridge augmentation. Dentin blocks showed less resorption than autogenous bone blocks.

Keywords: Alveolar ridge augmentation, dentin block, tooth transplantation, dental implants.

1. Introduction

Horizontal ridge augmentation of a deficient alveolar bone site is performed either simultaneously with implant placement or in a staged approach prior to implant insertion. There are several available strategies for the augmentation of alveolar ridge deficiencies, including guided bone regeneration through the use of resorbable and non-resorbable membranes, onlay and inlay grafts either by intraoral or extraoral block grafting, distraction osteogenesis, ridge splitting, free vascularized autografts, and maxillary sinus grafting (Aghaloo & Moy, 2007; Urban et al., 2013).

Augmentation using autogenous bone block is an effective technique with high success rates that exceed 95% even when major augmentation procedures had to be carried out for severely resorbed jaws (Stricker et al., 2003; Nkenke & Neukam, 2014). However, the limitations of autografts include donor site restriction and morbidity, unpredictable resorption, and limited bone availability (Nkenke & Neukam, 2014; Jensen et al., 2016). Chiapasco et al.,(2007) had a mean bone gain of 4.6 mm following horizontal ridge augmentation of atrophic mandibles by means of ramus bone blocks, and the mean bone resorption 4 months after the augmentation procedure before implant placement was 0.6 mm. At 1 year post-loading, the mean bone resorption was 0.3 mm, the resorption was 0.9 mm after 2 years and 1.1 mm after 4 years.

From a developmental point of view, teeth are derived from the neural crest, like maxillofacial bones and cartilage. Some studies have also expanded the potential use of teeth as a growth factor carrier and stem cells (Morrison et al., 1999; Yoshida et al., 2008). Dentin is considered a mineralized connective tissue, and its composition is nearly analogous to that of bone, dentin and bone had similar percentages of hydroxyapatite and collagen type I that serve as the main component of the dentin organic matrix, with a percentage composition of 90% (Kim et al., 2010). In addition, the rest of the non-collagenous proteins were osteopontin, osteocalcin, and dentin matrix protein 1. These proteins have the ability to trigger bone resorption and are involved in bone calcification (Linde 1989; Ye et al., 2004).

Because of the membranous origin of dentin that is nearly similar to that of bone, the direct deposition of new bone matrix on dentin membranous surfaces results in ankylosed dentin–bone interfaces (Andersson et al., 1984; Kim et al., 2013). For these reasons, it seems that dentin present a biological potential to support bone tissue regeneration (Atiya et al., 2014).

Dentin could be used in either block form or particulate form. Recently, the roots of extracted teeth (i.e., homologous root grafts) were successfully used as a block form for lateral alveolar ridge augmentation and supported the staged early osseointegration of titanium implants. It was concluded that tooth roots serve as alternative autografts for localized ridge augmentation (Schwarz et al., 2018). A recent systematic review evaluated the efficacy of autogenous teeth for the reconstruction of alveolar ridge deficiencies, it was conducted even with the limited studies involved relatively small patient samples and short follow-up periods but pointed to the potential of autogenous teeth to serve as an alternative material for the reconstruction of alveolar ridge deficiencies (Ramanauskaite et al., 2019). These outcomes have recently been confirmed in a proof of concept in a human case report by Elraee et al. (2020) in which the clinical re-entry at 24 weeks revealed that the transplanted root derived from a retained lower wisdom tooth was homogeneously incorporated at the former defect site. The gain in ridge width amounted to 4.5 mm, and histological assessment revealed cortical bone formation at the buccal and lingual aspects between the tooth and the bone, with a successfully osteointegrated dental implant.

Therefore, this randomized controlled clinical study aimed to assess and compare the efficacy and safety of autogenous tooth roots for lateral alveolar ridge augmentation in addition to histologically assessing the remodeling behavior of dentin block after horizontal ridge augmentation. To the best of our knowledge, there is no controlled clinical trial showing a histological analysis of autogenous tooth block in the current literature.

2 . Material and Methods

2.1 Study design and registration

The current study was designed a randomized controlled clinical trial that was carried out in accordance with CONSORT guidelines. In this study, a 1:1 allocation ratio was used to compare dentin block group (D-group) (test group) with autogenous ramus bone block (A-group) (control group). The research protocol was registered on www.clinical trials.gov in February 2018 (NCT04266652). Research protocol, informed consent templates, and biological sample collection requests were approved by the Research Ethics Committee of the Faculty of Dentistry, Ain Shams University (FDASU-Rec M 181003). The study was carried out in compliance with the ethical principles of the Declaration of Helsinki for medical research involving human subjects as revised in Seoul in 2008. This study was done in accordance with the Consolidated Standards of Reporting Trials (CONSORT)guidelines.

2.2 Recruitment of participants

The study was conducted at the Faculty of Dentistry, Ain Shams University, Egypt. Participants were recruited from the university clinic, and study procedures were conducted at the postgraduate periodontology clinic at the Department of Oral Medicine and Periodontology, Faculty of Dentistry, Ain Shams University**.** The inclusion criteria were a missing single upper central incisor with moderate horizontal defect 4–8 mm according to the Cologne Classification (2013), sufficient bone height at the recipient site for implant placement, healthy oral mucosa with at least 3-mm keratinized tissue, and the presence of lower impacted wisdom teeth free from periapical infection.

The exclusion criteria were patients reporting systemic conditions that may compromise healing or bone metabolism (e.g., uncontrolled diabetes and hyperthyroidism); history of radiotherapy, chemotherapy, or bisphosphonate therapy; pregnancy or females who a plan to get pregnant during the course of the study; and smoker patients.

2.3 Outcomes

Primary outcome was the mean overall clinical ridge width gain (CRWG) after 6 months of augmentation. Secondary outcomes were the overall radiographic ridge width gain (RRWG) after 6 months of augmentation and descriptive histological analysis with histomorphometric assessment of bone fraction %.

2.4 Sample size determination

Regarding sample size calculation, the study population consisted of two groups. The number of patients in each group was determined through power analysis for the present study used overall clinical gain of ridge width after 6 months as the primary outcome. Based upon the results of Schwarz F et al. (2018); the mean and standard deviation values for gain in ridge width were 5.53 (1.88) and 3.93 (1.41) mm, respectively. The effect size (d) was 0.963. Effect size was calculated based upon the following formula: $d = (M1-M2)/Sp$, where M1 and M2 denote the sample means for groups 1 and 2 and Sp denotes the pooled estimated population standard deviation. Using alpha (α) level of (5%) and Beta (β) level of (20%) i.e. power = 80%; the minimum estimated sample size was 18 cases per group. Sample size was increases to 21 cases per group to compensate for a drop-out rate of 15% after 6 months. Sample size calculation was performed using G*Power Version 3.1.9.2.

2.5 Randomization

Alveolar ridges were randomly assigned to undergo lateral ridge augmentation using either D-group (test group) or A-group (control group) with a 1:1 allocation ratio. Sequence generation and concealment were carried out by a single investigator (HH) using www.random.org. Allocation was concealed in serially numbered, identical and opaque sealed envelopes. DA-K was responsible for assigning the allocation of participants into the corresponding study group. All participants were enrolled and equally prepared for the surgical procedure by a single investigator (LE). Immediately before the surgery the intervention allocation was revealed by (DA-K) to the investigator (LE) according to the sequence generated.

2.6 Blinding

Study participants were blinded to the treatment received. Blinding of the surgeon was not possible. Blinding of the outcomes assessors were not possible since the radiograph and histology was totally remarkable. The current clinical trial was blinded by the biostatistician. The radiographic and histological assessment was done by HK and DA-K.

2.7 Preoperative clinical and radiographic examination

Professional periodontal debridement was performed, and oral hygiene techniques were explained and emphasized. Following detailed explanation of the aim of the study, benefits to participants, surgical procedures, harms and timeline, participants read and undersigned informed consents. Preoperative cone beam computed tomography (CBCT) was performed before ridge augmentation with exposure parameters of 85 KVp, 15 mA, and 6 cm field of view in order to evaluate recipient and donor sites. The radiographs were analyzed using One-Viewer viewing software (3DiCATVision), the buccolingual width was measured into different levels: at the bone crest, 3 mm from the bone crest, and 6 mm from the bone crest. Then, the mean of the three measurments was taken. Horizontal ridge dimentions was measured clinically using bone caliper (StarVent^{TM}, USA) prior to the surgery at three different levels: the crest, middle, apex, with a distance of 3 mm between each level. Then, the mean of the three measurements was calculated. All procedures were carried out under local anesthesia with 4% epinephrine 1:100,000 (Artinibsa 40 mg; Lliçà de Vall, Spain).

2.8 Surgical procedures

All the surgeries were performed by one periodontist (LE). For the recipient site, a pyramidal full-thickness flap was elevated by making a crestal incision with two vertical anterior and posterior incisions that extended to the vestibule. The labial mucosa was reflected until 2 mm apical to the mucogingival junction. The bone crest and labial surface were curetted to remove all soft tissue. The recipient site was decorticated by a 0.8-mm bur to penetrate the underlying marrow and improve the blood supply to the graft. In the D-group, the partially impacted or malpositioned third molar was surgically removed carefully to ensure the removal of the roots without any fracture. In some cases, if there was the ability to extract the molar without removing the crown, the graft preparation started with the crown being decapitated using a rotating carbide bur under gentle sterile saline cooling. A separated tooth root was adapted to match the size and shape of the defect area. Extracted teeth were cleaned from periodontal ligaments, and soft tissue attachment using a high-speed fine finishing stone and saline irrigation. The pulp chamber was cleaned with sterile endodontic files to make sure that dental pulp was totally removed. In order to improve ankylosis between the graft and the defect site, the layer of cementum was carefully removed until the underlying dentin was entirely exposed from all tooth sites and the final width of the dentin block was 4 mm (Figure 1a–g).

In the case of the A-group, a full-thickness mucoperiosteal incision was made distal to the most posterior tooth in the mandible to the retromolar pad and ascending ramus. A submarginal incision was performed along the mucogingival line to minimize scar tissue formation and facilitate the suturing procedure. A full-thickness mucoperiosteal flap was then reflected, and the monocortical block graft was harvested using piezoelectric surgery (Piezotome Solo M, Comeg, France). Both dentin and bone blocks were fixed to the recipient site with one or two self-tapping titanium screws (leader medical,Via dell'Industria,Italy). Following graft fixation, any sharp margins were smoothened to avoid postoperative exposure or dehiscence (Fig. 2 a-c).

The overlying flap was released by periosteal releasing incision before being sutured in a tension-free closure. Flap closure was accomplished through horizontal mattress and simple interrupted sutures using 5-0 polypropylene sutures (Oralsply, Dtek, Tao-Yuan, Taiwan) for the crestal and releasing incisions.

2.9 Postoperative care

All patients received antibiotics for 1 week in the form of twice daily 1-g Augmentin for 7 days (GlaxoSmithKline, Egypt), 500-mg metronidazole three times per day for 7 days (Flagyl; Sanofi Aventis, Egypt), anti-inflammatory tablets three times per day for 7 days (Alphintern; Amoun, Egypt) and Ibuprofen 600 mg (Brufen, Kahira Pharmaceuticals, Egypt) in case of severe pain. Patients were instructed to rinse their mouths twice daily with a 0.12% chlorherxidine digluconate (Antiseptol; Kahira pharm, Egypt) mouth rinse and to avoid mechanical plaque removal at the site of surgery for 15–30 days. Ice packs were placed over the donor and recipient sites immediately. Patients were instructed to be on a soft diet during the first days. Sutures were removed 14 days after surgery.

2.10 Assessment of Clinical and Radiographic Outcomes

Six months following the healing, the patient underwent CBCT for graft site evaluation and to determine the dimensions of the implant to be placed. Ridge dimentional change was assessed clinically using bone caliper prior to the second surgery (implant placement). A mucoperiosteal flap was elevated to expose the grafted area in each group, followed by a gentle removal of the osteosynthesis screw; a core biopsy sample with a 2.5-mm diameter was taken using a trephine bur (smithcare trephine bur). No separartion between dentin block and native bone was present in any cases. After obtaining a core biopsy started with drilling for implant placement using sequential drills, an implant (Dentium SuperLine II,Gangan-gu, Seoul, South Korea) is placed and allowed for submerged healing (Figure 2 d-f, 3 a–d).

Inter and intra observer for the clinical ridge width with 1 week interval and there was a very good agreement by using ICC, preoperative clinical ridge width ICC 0.742 (95% confidence interval 0.711- 0.765), immediately postoperative clinical ridge width ICC 0.72 (95% confidence interval 0.69- 0.759) and , 6 months postoperative clinical ridge width ICC 0.854 (95% confidence interval 0.812- 0.889).

Regarding the clinical evaluation the ridge dimentions was assessed clinically by bone caliper preoperatively, immediately after the surgery and 6 months postoperatively. The measurement was performed with fixed points each time, the buccolingual width was measured at different levels. At the bone crest, 3mm from the bone crest and 6mm from the bone crest. The mean overall CRWG was calculated as the difference between 6 months postoperative and preoperative readings.

CBCT scans were performed using i-CAT Next Generation (Imaging Sciences International, Hatfield,Pa) with exposure parameters of 85 KVp, 15 mA and 6 cm field of view (FOV). The radiographic evaluation was done using CBCT data (3DiCATVision) and OnDemand 3D application software. CBCT were obtained preoperatively, immediately postoperatively and 6 months postoperatively. The radiographs were analyzed using One- Viewer viewing software (iCATVision). The buccolingual width was measured into different levels. At the bone crest (A), 3mm from the bone crest (B) and 6 mm from the bone crest (C). For standardization in the sagittal slice, the axial plane was adjusted to pass through the cemento enamel junction (CEJ) of the adjacent teeth. On the axial slice, the mesiodistal dimension from the distal surface to mesial surface of the adjeceent teeth was measured. The coronal plane was adjusted to be pass through the middle of the distance in order to be perpendicular to both buccal and lingual cortices. Measurement were all performed on the coronal slices. In addition, fusion was done by superimposing preoperative and 6 months CBCT in both groups. The mean overall RRWG was calculated as the difference between 6 months postoperative and preoperative radiographic readings.

2.11 Histological Preparation and Analysis.

The biopsy samples were fixed in 10% formalin for 2 days, decalcified for 14 days in 5% Ethylenediaminetetraacetic acid (EDTA) (pH 7.0), and prepared according to standard protocols. The entire core biopsy was embedded into paraffin wax (Shadon Histocentre 3, Thermo Fisher Scientific Inc., Kalamazoo, MI, USA). All samples were serially sectioned using a microtome (Leica RM2025, Germany). Four serial 5-μm-thin sections were collected every 200 microns for histomorphometric analyses. Slides were stained separately with hematoxylin and eosin and observed using a light microscope. For histological evaluation and histomorphometric analysis, 20 photomicrographs from different sections taken at every 200 μm of each biopsy sample were captured at original magnification 10×, 20×, and 40× using a digital camera (C5060, Olympus, Japan) mounted using a C-mount to a light microscope (BX60, Olympus, Japan). All the steps for histomorphometric evaluation of bone, residual dentin, and fibrous tissue percentages were carried out using image analysis software

(ImageJ, 1.41a, NIH, USA). The image analyzer was calibrated to automatically convert the measurement units (pixels) produced by the image analyzer program into actual micrometer units. Data from the sections of each scaffold were averaged.

2.12 Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Shapiro-Wilk tests) and Levene test were used for equality of variances and the results revealed presence of homoscedasticity. All data showed normal (parametric) distribution. Parametric data were presented as mean and standard deviation (SD) values. Student's t-test was used to compare between mean age, bone gain and histomorphometric data in the two groups. Mixed model ANOVA (Between-within group) was used to compare between the groups at each follow up period as well as to study the changes by time within each group. Bonferroni's post-hoc test was used for pair-wise comparisons when ANOVA test is significant. Gender data were presented as frequencies and percentage and compared using Chi-square test. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

3. Results

Forty-two patients were included in this study with missing upper central incisors. There was no statistically significant difference between the mean ages of the two groups (30.1 ± 6.5 years in the D-group and 28.7 ±4.4 years in the A-group). There was also no statistically significant difference between gender distributions in the two groups: nine men and twelve women in the dentin block group and eight men and thirteen women in the autogenous bone block group (Table 1). Wound healing was uneventful in all of the treated cases.

3.1 Clinical analysis

In the D-group, clinical ridge dimensions increased from 4.29 mm preoperatively to 8.36 and 7.81 mm immediate post operatively and 6 months post operatively, respectively. However, In the A-group, there was an increase in the clinical ridge width from 4.33 mm preoperatively to 8.17 mm and

6.57 mm immediately following the surgery and 6 months post operatively, respectively. There was a statistically significant difference between D- and A-groups at 6 month follow-up (P <0.001, ANOVA). The overall CRWG was 3.52 and 2.24 mm in the D and A groups, respectively, with a statistically significant difference between them (P <0.001, Student's t-test). The clinical ridge dimensions decreased by 0.55 mm between the immediate postoperatively and 6 months postoperatively in the D-group, and decreased by 1.6 mm between the immediate postoperative and 6 months postoperatively in the A-group, with a statistically significant difference between the two values (P <0.001, ANOVA). (Tables 2-4).

3.2 Radiographic analysis

In the D-group, the radiographic ridge dimensions increased from 4.4 mm preoperatively to 8.49 and 8.01 mm immediate post operatively and 6 months post operatively respectively. Conversely, in the A-group, there was an increase in the radiographic ridge dimensions from 4 mm preoperatively to 8.46 and 7.41 mm immediate postoperatively and 6 months post operatively respectively. The overall RRWG was 3.61 and 3.41 mm in the D and A groups, respectively, there was no statistically significant difference between D- and A-groups pre- or immediately post operatively (p = 0.062, effect size 0.082, and p = 0.941, effect size 0.0001, respectively). After 6 months, D-group showed statistically significantly higher mean radiographic ridge widths compared to the A-group (P-value = 0.034, Effect size = 0.108) (Tables 2 -4 and Figures 4, 5).

3.3 Histomorphometric analysis

The histomorphometric analysis of the bone area fraction was 42.6 % and 41.3 % in the D and A groups, respectively, without any statistically significant difference between the two values (P = 0.89, Student's t-test). The fibrous tissue fraction area was 6.7% and 4.6% in the D and A groups, respectively, without any statistically significant difference between the two values (P = 0.7, t-test). In addition, the percentage of residual dentin in D-group was 31.5% (Figure 6).

Regarding the D- group, histological evaluation revealed new bone formation and viable cells and matrix on the dentin block periphery. The presence of a well-organized woven bone and cementoid tissue suggests the remodeling of the dentin block and supports new bone deposition.

Newly formed osteoid tissue was deposited in the connection between the dentin block and native bone, which had osteocytes and vessels. Cellular fusion without fibrous tissue was observed at the border between the osteoid and the dentin matrix (Figure 7a-d).

Regarding the A-group, most of the bone was surrounded with fibrous tissue with less evidence of new bone formation in addition to the fibrous tissue connection between native bone and the new bone block, and the mineralizing matrix showed haphazard new bone formation (Figure 8a-d).

4. Discussion

From a clinical point of view, extracted teeth are a recent treatment alternative to autogenous bone for grafting purposes in block and particulate forms Kim et al. (2011) demonstrated that the autogenous tooth has excellent bone repair abilities because of its osteoinduction and osteoconduction abilities and its possible application in localized ridge augmentation with moderate defects. Autogenous dentin block has a lot of advantages, such as its osteoinduction capacity via blood wettability, and its creeping substitution and space-maintaining abilities. It is remodeled by maintaining a space over a specific period (Park et al., 2012).

Based on the present randomized clinical trials, the overall CRWG 6 months following augmentation was 3.52 and 2.24 mm in the D and A groups, respectively, with a statistically significant difference between the two groups. The RRWG was 3.61 mm and 3.41 mm in the D and A groups, respectively, without any statistically significant difference between the two groups. In our study, the CRWG in autogenous dentin block was 3.52 mm. This finding is in line with that of Schwarz et al., (2018), which had a mean clinical ridge dimentional gain of 4.53 ± 1.54 mm in the tooth root group. However, the CRWG in autogenous bone block was 2.2 mm, which was in accordance with horizontal ridge augmentation of atrophic mandibles by means of bone blocks harvested from mandibular ramus that had a mean bone gain of 4.6 mm (Chiapasco et al., 2007).

The dentin block was shaped according to the defective site at chairside immediately after wisdom tooth extraction. In the present study, during the re-entry 6 months post-augmentation, the tooth root firmly adhered to native bone, the implant was placed with high primary stability to the dentin and it was previously proved by experimental studies that there is basal ankylosis and replacement resorption of the exposed dentinal matrix facing the alveolar bone (Becker et al., 2017).

The CBCT measurements of the alveolar ridges were carried out on three occasions throughout this study. The overall RRWG was 3.61 and 3.41 mm in the D and A groups, respectively, without any statistically significant difference between the two values. The radiographic ridge dimensions decreased by 0.48 mm between the immediate post operative and 6 months postoperatively in the D-group and decreased by 1.06 mm between the immediate post operative and 6 months postoperatively in the A-group, According to the clinical results, these also show the minimum resorption of the dentin block comparable with the bone block group. The results of our study was in accordance to Schwarz et al. (2019) that showed clinical bone gain with tooth blocks was 4.89 ± 2.29 mm 24 weeks following augmentation with a resorption rate of 1.39 ± 1.53 mm.

The histomorphometric analysis revealed around 42% bone area fraction in both D and A groups. This may be attributed that tooth roots are biocompatible and allow new bone apposition where a new area of calcification and matrix formation were found andarea of hard tissue formation that would be likely a cementoid tissue. On the contrary, bone block was a mixture of old and new bone formation and contained mostly the native bone. The residual dentin% in the D-group were 30% which confirms that tooth block slowly resorbed and takes a longer time than 6 months to get resorbed.

Histological evaluation revealed that, some cases showed a proper integration between the dentin block and native bone with new hard tissue formation. In one case, a gap between the dentin block and bone could be detected, whereas in other areas, a fibrous tissue connection was shown. The presence of a well-organized woven bone and cementoid tissue suggests the remodeling of the dentin block and supports new bone deposition. The dentin could possibly only be remodelled by granulation tissue, in the present study the presence of fibrous tissue in both dentin and bone blocks prove this theory. Histologically, animal experiments showed a substitutive resorption of the dentin and a contact area, osteodentin had established a close contact withthe titanium surface and the dentin, which was comparable results to autogenous bone blocks. In the region of direct contact between dentin and titanium implant surface, the formation of root cementum and mineralized hard tissue could be identified histologically (Baumer et al., 2015; Becker et al., 2017).

The results of the histological assessment were in accordance with the findings of Parvini et al., (2020), which showed that tooth roots have different remodeling patterns following vertical bone augmentation in beagle dogs. Tooth roots in one animal were separated from the native bone. Other specimens showed different degrees of maturation of mineralized tissue that were subsequently invaded by woven bone with gradual resorption of tooth roots. Some cases show a proper integration between the dentin block and native bone with new hard tissue formation; in other areas, just a gap between the dentin block and bone is shown, whereas in other areas, a fibrous tissue connection is shown.

In this essence, dentin block restores bone volume and quality, which are prerequisites for the primary stability of implants. Compared with other techniques, dentin block prevents bone harvesting procedures and consequent surgical injury at donor sites. Surgical cost is also reduced because no additional material is needed. However, the use of the dentin block technique is limited in certain cases in which non-functioning teeth provide sources for dentin block, and this technique is not applicable for patients with no donor tooth or root. The present clinical study revealed that dentin block may serve as an alternative graft to support horizontal alveolar ridge augmentation and two-stage implant placement.

One of the limitations of the present study was the enrollment of only patients that have non restorable wisdom tooth, the recipient site should be as small as the root of the wisdom tooth and the possible risk of root fracture during extraction. Secondly, the lack of reporting upon the clinical outcomes of dental implants inserted into the grafted sites represents another limitation of the analysis.

5. Conclusion

The present clinical study revealed that dentin block may serve as an alternative graft to support horizontal alveolar ridge augmentation. Dentin blocks showed less resorption than autogenous bone blocks.

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Conflict of Interests and Source of Funding

The authors declare that they have no conflict of interests related to this study.

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Figure Legends

Fig. 1. a: Horizontal impacted lower right wisdom tooth, b: wisdom tooth after extraction, c: extracted root before preparation, d: pyramidal full-thickness flap elevation, e: recipient site decortication, f: dentin block fixation to the recipient site, and g: flap suturing.

Fig. 2. a: full thickness flap reflection, b: bone block fixation , c: flap closure, d: Flap reflection 6 months following bone block graft, e: core biopsy obtaining,f: implant placement.

Fig. 3. a: Flap reflection 6 months following dentin block graft, b: core biopsy obtaining, c: trephine bur, d: implant placement.

Fig. 4. a: Preoperative CBCT of dentin block group measuring. b: CBCT measurements immediately after augmentation dentin block augmentation. c: CBCT 6 moths months after dentin block augmentation with the following measurements, d, e. Fusion between preoperative and 6 months postooperative CBCT.

Fig. 5. a: Preoperative CBCT of bone block group. b: CBCT of immediately postoperative augmentation with bone block. c: CBCT 6 months after bone block augmentation. d, e. Fusion between preoperative and 6 months postooperative CBCT.

Fig. 6. Bar graph illustrating histomorphomretric ansalysis in the dentin block and bone block groups.

Fig. 7. Photomicrographs of H&E stained sections of core biopsy from dentin block with different maginficatons, a, b image showig residual dentin (green arrow) (orig. mag. 4x, 10x), c. fibrous tissue connection (red arrow) between native bone (yellow arrow) and dentin block (green arrow), in addition to connected by mineralizing matrix with viable cells (orig. mag. x20), d. osteoid formation with viable cells and minralizing matrix at the periphery of dentin block (green arrow) (orig. mag. 40x).

Fig. 8. Photomicrographs of H&E-stained sections of core biopsy from bone block with different magnifications. a: Image showing residual bone (black arrow) and new bone (green arrow) with fibrous tissue connection between them (red arrow) (original magnification: 20×). d: Mineralizing matrix and haphazard bone lacunae in new bone (green arrow) and well-organized old bone (black arrow) (original magnification: 40×).

Table 1: Mean, standard deviation (SD), frequencies (n), percentages and results of Student's t-test and Chi-square test for comparison between baseline characteristics of the two groups

	Dentin block (n = 21)	Autogenous bone block (n = 21)	*P*-value
Age (Years)			
Mean (SD)	30.1 (6.5)	28.7 (4.4)	0.419
Gender [n (%)]			
Male	9 (42.9)	8 (38.1)	0.753
Female	12 (57.1)	13 (61.9)	

Table 2: Descriptive statistics and results of mixed model ANOVA test for comparison between bone width measurements (mm) in the two groups

Measurement	Time	Dentin block (n = 21)		Autogenous bone block (n = 21)		*P*-value	*Effect size (Partial Eta Squared)*
		Mean	SD	Mean	SD		
Clinical	Pre-operative	4.29	0.49	4.33	0.48	0.753	0.003
	Post-operative	8.36	0.73	8.17	1.43	0.589	0.007
	6 months	7.81	0.75	6.57	1.08	<0.001*	0.319
Radiographic	Pre-operative	4.4	0.49	4	0.62	0.062	0.082
	Post-operative	8.49	0.69	8.46	1.62	0.941	0.0001
	6 months	8.01	0.62	7.41	1.07	0.034*	0.108

*: *Significant at* $P \leq 0.05$

Table 3: Descriptive statistics and results of mixed model ANOVA test for comparison between bone width measurements (mm) at different follow up times in each group

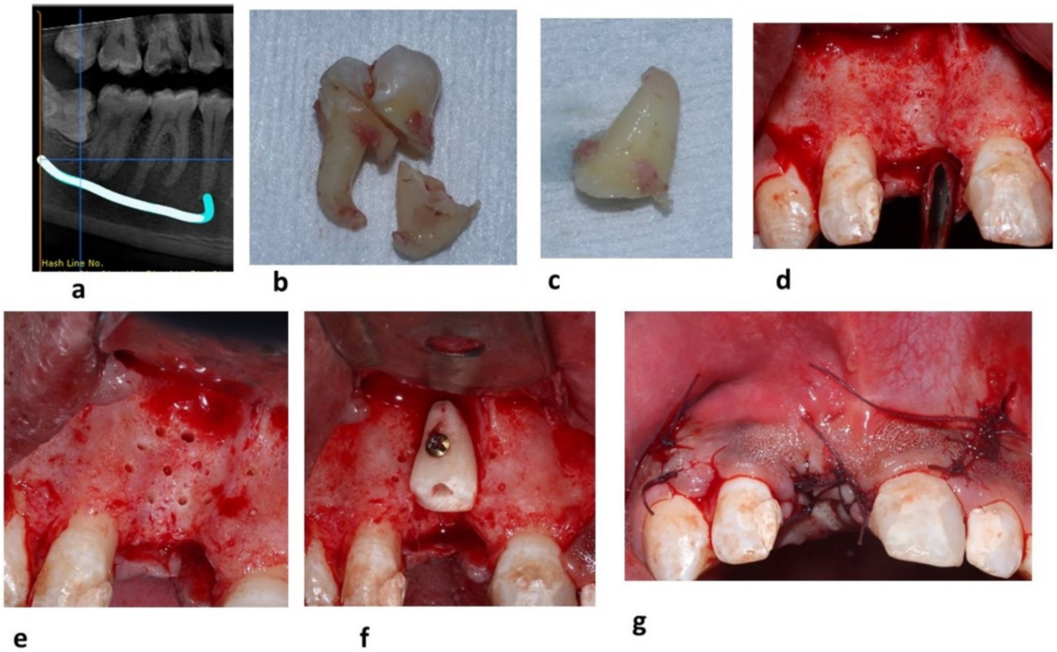
Measurement	Group	Pre-operative		Post-operative		6 months		*P*-value	*Effect size (Partial Eta Squared)*
		Mean	SD	Mean	SD	Mean	SD		
Clinical	Dentin block	4.29^{C}	0.49	8.36^{A}	0.73	7.81^{B}	0.75	<0.001*	0.896
	Autogenous bone block	4.33^{C}	0.48	8.17^{A}	1.43	6.57^{B}	1.08	<0.001*	0.859
Radiographic	Dentin block	4.4^{C}	0.49	8.49^{A}	0.69	8.01^{B}	0.62	<0.001*	0.89
	Autogenous bone block	4^{C}	0.62	8.46^{A}	1.62	7.41^{B}	1.07	<0.001*	0.885

*: *Significant at $P \leq 0.05$, Different superscripts in the same row indicate statistically significant change by time*

Table 4: Descriptive statistics and results of Student's t-test for comparison between bone gain (mm) after six months in the two groups

Time	Dentin block (n = 21)		Autogenous bone block (n = 21)		*P*-value	*Effect size (d)*
	Mean	SD	Mean	SD		
Clinical	3.52	0.56	2.24	0.86	<0.001*	1.764
Radiographic	3.61	0.61	3.41	1.15	0.494	0.213

*: *Significant at $P \leq 0.05$ssss*



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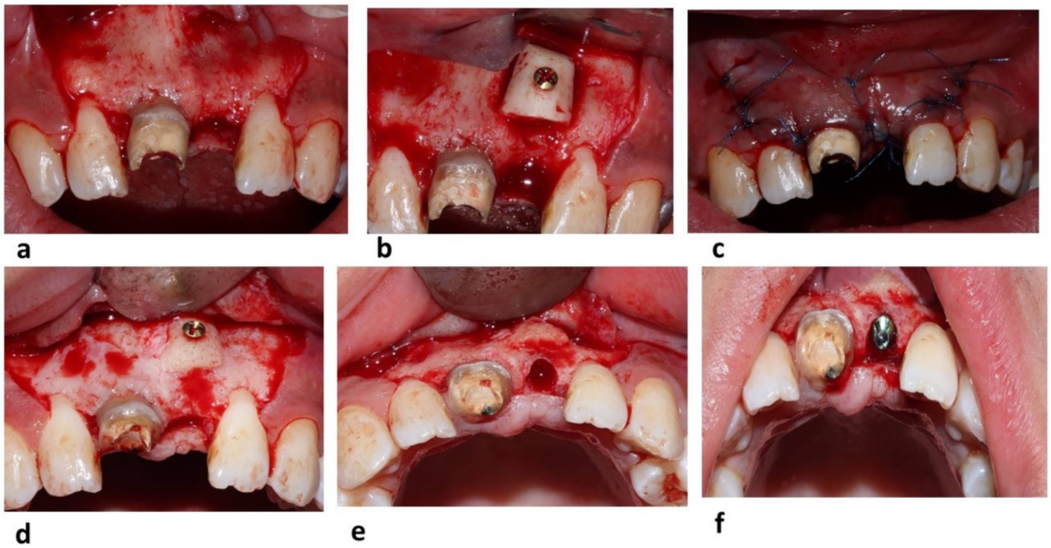

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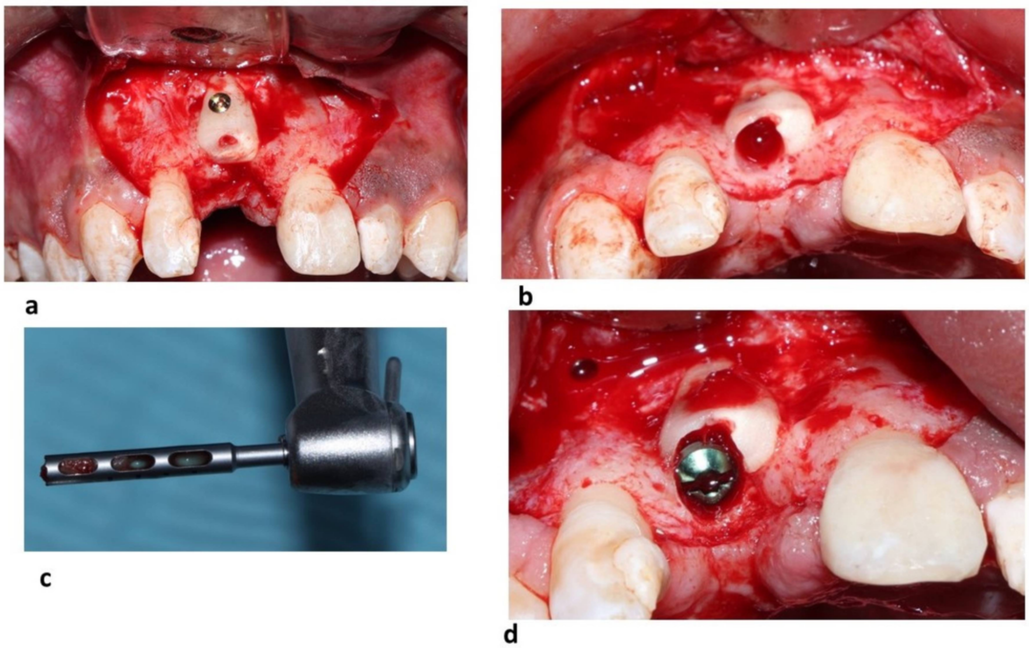

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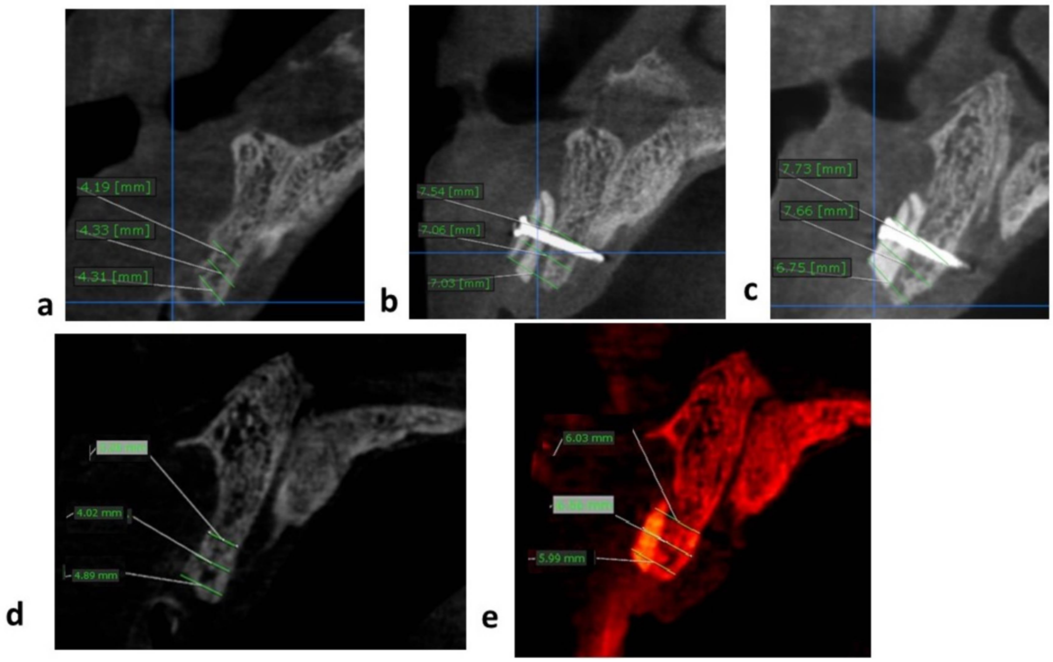

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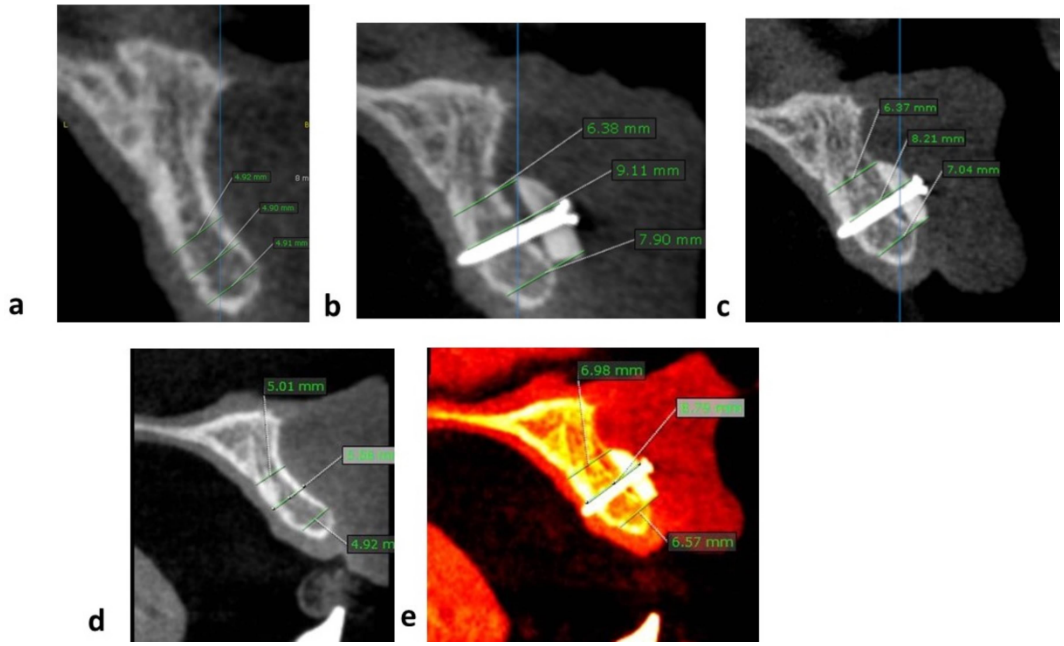

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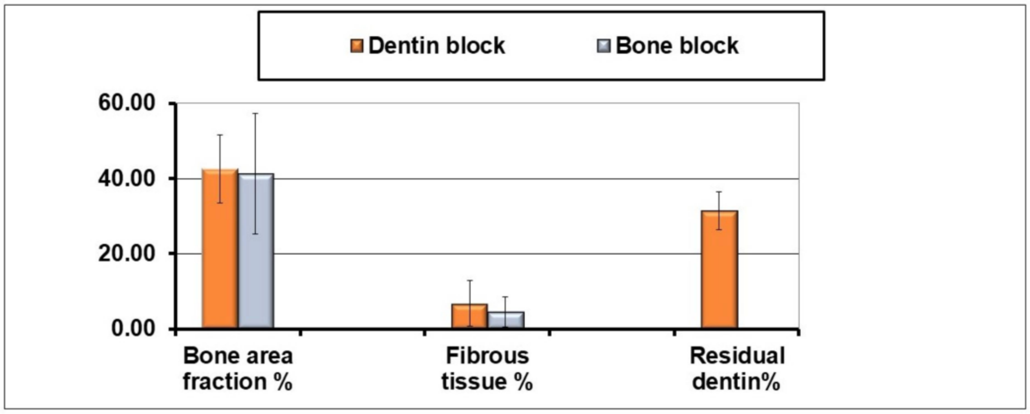

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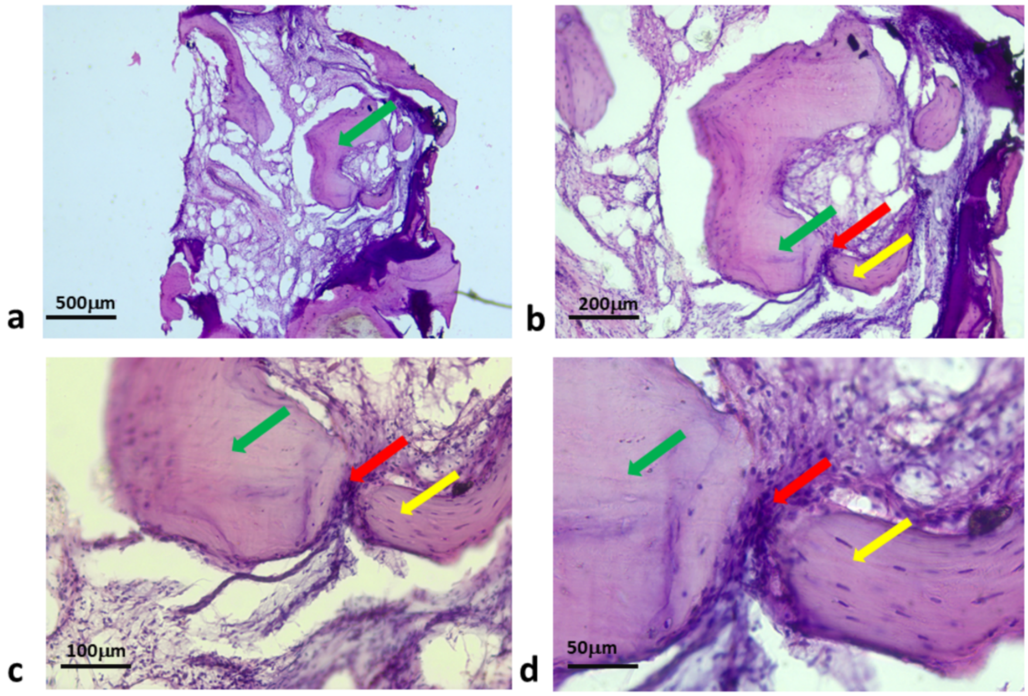

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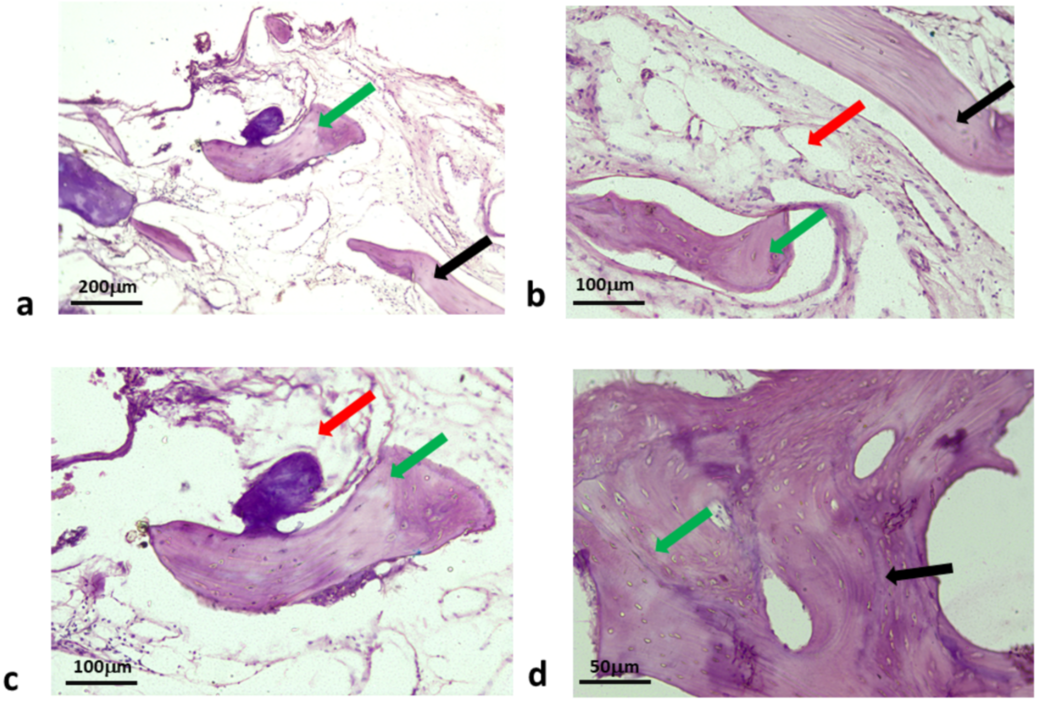

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