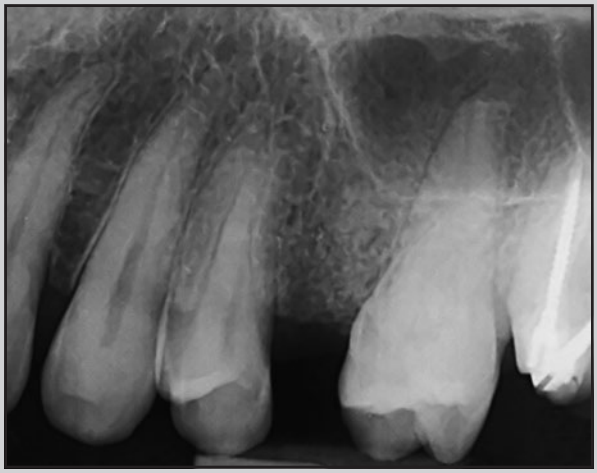
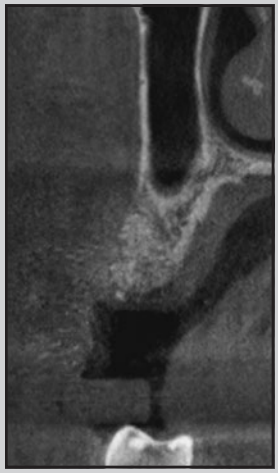
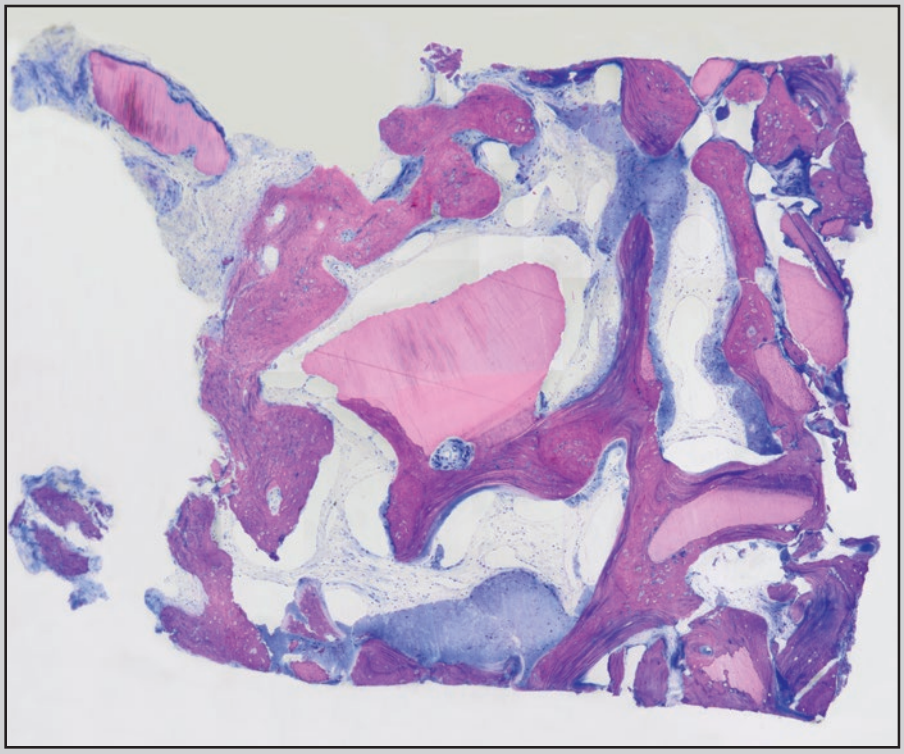
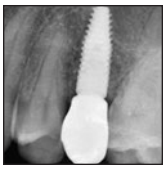






New Bone Formation Using an Extracted Tooth as a Biomaterial: A Case Report with Histologic Evidence



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Myron Nevins, DDS[2]
Peter Schupbach, PhD[3]

This case report aims to demonstrate the regenerative potential of particles obtained from a crushed extracted tooth. Following tooth removal, the clean root was ground and the dentin and cementum granules were grafted into a fresh extraction socket for a ridge preservation procedure. After 24 weeks, a successful implant placement was allowed. Tissue healing was evaluated by histologic and radiologic analysis. The volume of the ridge was preserved. Histologically, a dentin-bone complex was reported. New bone formation was evident, with an intimate contact between bone and both dentin/cementum. This novel procedure suggests the use of tooth particles as graft material.
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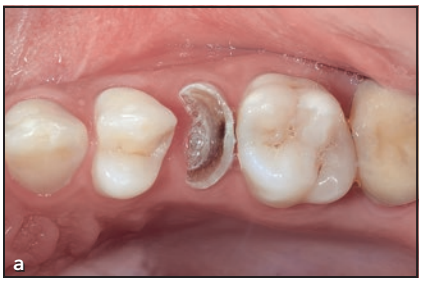
Various graft materials can be used for bone regeneration in implant dentistry, including autogenous bone, allografts, xenografts, and alloplasts.[1,2] There is a suggestion that teeth can also be used as bone graft material. From a developmental point of view, teeth derive from the neural crest, like maxillofacial bones and cartilage.[3,4] Dentin and cementum contain proteins in common with bone, such as osteocalcin, osteopontin, bone sialoprotein, dentin matrix protein, and collagen type I.[5–7] Moreover, by weight and by volume, dentin and bone present a similar percentage of collagen and hydroxyapatite.[8,9] Dentin also contains several growth factors, such as bone morphogenetic protein 2 (BMP-2) and transforming growth factor (TGF), that play a significant role in bone formation.[10] For these reasons, it seems that dental tissues present a biologic potential to support bone tissue regeneration.[11–14]

While some evidence exists regarding the use of dentin as a bone graft in experimental studies on animals,[15,16] none have demonstrated its use on patients. Therefore the present authors investigated the use of extracted teeth to support bone tissue regeneration. The goal of this report is to clinically, histologically, and radiologically evaluate the healing and bone formation



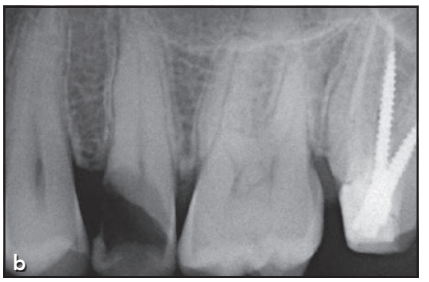


Fig 1 (a) *Intraoral view at baseline showing the carious lesion on the left second premolar.* (b) *Intraoral radiograph at baseline demonstrating the advanced carious lesion.*

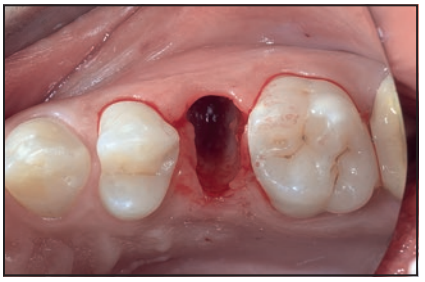
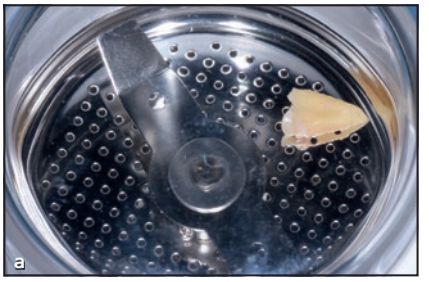


Fig 2 *The tooth is extracted with a minimally invasive flapless approach, preserving the integrity of the socket.*



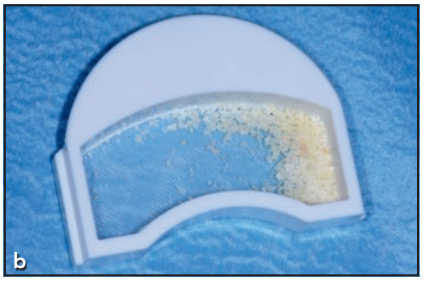


Fig 3 (a) *The extracted root is dried and placed into the sterile grinding chamber.* (b) *Tooth particles between 300 and 1200 µm are collected in the drawer chamber.*

in a human extraction defect using crushed dentin particles.

Materials and Methods

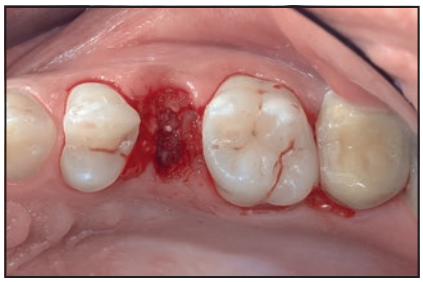
A 35-year-old nonsmoking and systemically healthy woman who exhibited a hopeless left second premolar in the maxillary arch was selected. Due to a penetrating carious lesion affecting both the crown and the root, the tooth was considered for extraction (Fig 1). The treatment plan consisted of a tooth extraction and ridge preservation using particles of the extracted tooth, followed by implant placement after a 24-week healing period. The patient fully understood the nature of the proposed treatment and signed an informed consent form.

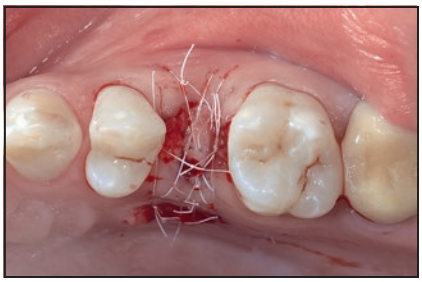
Local anesthesia was performed using articain 4% with epinephrine 1:100.000. Following luxation of the root, the tooth was flaplessly extracted using a heavy periotome, maintaining the original anatomy of the soft tissues. The socket was debrided and rinsed with saline solution (Fig 2). After its removal, the tooth was cleaned using a rotating diamond-coated bur under gentle irrigation cooling with sterile saline, and the exposed pulp was endodontically removed. Then, the root was crushed using a tooth grinder specifically engineered for the purpose of creating a bacteria-free particulate autogenous mineralized dentin graft (Smart Dentin Grinder, KometaBio). The grinder has been devised to crush and sort extracted teeth into a specific-size dentin particulate.

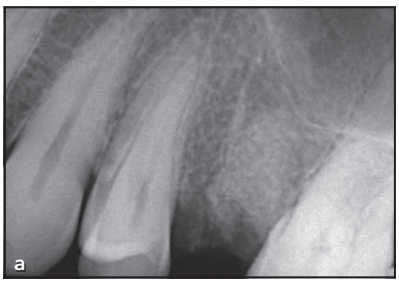
To start the process, the tooth is dried by air syringe and then put into the sterile grinding chamber (Fig 3a). The Smart Dentin Grinder is capable of grinding the tooth in 3 seconds and then, by 20-second vibrating movement of the grinding chamber, the particles of less than 1,200-µm size fall through a sieve to a lower chamber that keeps all particles sized between 300 and 1,200 µm (Fig 3b). Particles smaller than 300 µm fall into a waste drawer, as this fine particulate is considered a nonefficient particulate size for bone grafting. This grinding and sorting protocol is repeated to grind the remaining tooth particles left in the grinding chamber. In the collecting drawer chamber, dentin particles between 300 and 1,200 µm are collected. The particulate dentin

Fig 4 (left) *The fresh socket has been accurately grafted with the dentin and cementum particles.*

Fig 5 (right) *The socket is sealed with a connective tissue graft, aiming to cover and protect the dentin graft.*







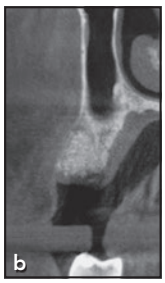


Fig 6 (a) *Intraoral radiograph showing the alveolus at the end of the surgical procedure. The lamina dura is visible, and the socket appears to be filled with the dentin particles. The socket is sealed with a connective tissue graft.* (b) *Cone beam computed tomography evaluation at the end of the surgical procedure. The thin buccal plate can be noted.*

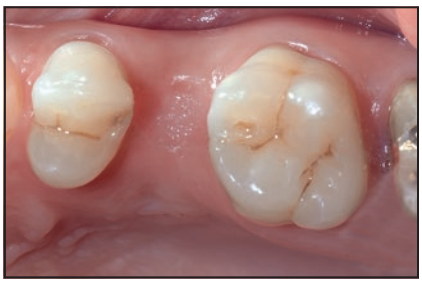


Fig 7 *Intraoral view after 5 months of healing. The soft tissues are mature, and the horizontal dimension of the ridge is preserved.*

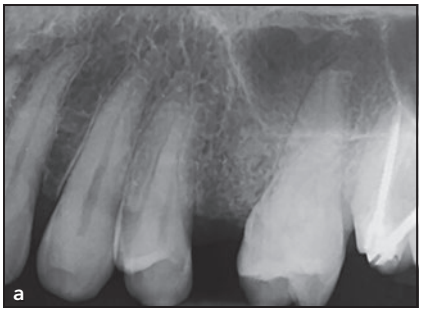
from the drawer is immersed in basic alcohol in a small sterile glass container for 10 minutes. The basic alcohol cleanser consisted of 0.5 M of NaOH and 30% alcohol for defatting and dissolving all organic debris, bacteria, and toxins of the dentin particulate. The cleanser is able to dissolve all the organic debris from dentin particulate, including dentin tubules.[17]

After decanting the basic alcohol cleanser, the particulate is washed in sterile phosphate-buffered saline. The phosphate-buffered saline is decanted, leaving wet particulate dentin ready to graft into bone defects. The process of extracting the tooth and having it ready as a grafting material takes approximately 15 to 20 minutes. It should be noted that the efficiency of selecting the dentin particulate of specific size for grafting is more than 95%. It is obvious that the volume of the particulate dentin is more than twice of the original root volume.

The empty extraction socket was filled with the dentin graft. The particles were accurately packed using a bone plugger (Cardaropoli, Omnia) to fill the socket to the crestal level (Fig 4). The graft was covered with a connective tissue graft just harvested on the palate (Fig 5) and secured to the surrounding soft tissues using a combination of single and mattress nonresorbable sutures (PTFE 5/0, Omnia).

A gel rich in hyaluronic acid and four aminoacids (Aminogam, Errekappa) was applied over the connective tissue graft to enhance wound healing. At the end of the surgery, an intraoral radiogram (Fig 6a) was performed together with a tridimensional evaluation (Fig 6b). Cone beam computed tomography (CBCT) was performed using a 5 × 5-cm field of view, with 90-µm scans (CS9300, Carestream).

Postoperatively, the patient was prescribed oral antibiotic therapy, with amoxicillin plus clavulanate potassium (1 g) every 12 hours for 6 days (Augmentin, GlaxoSmithKline), nonsteroidal analgesic ibuprofen (600 mg) as needed (Brufen, Abbott), and a chlorhexidine gluconate 0.2% rinse three times a day (Curasept ADS 0.2%, Curaden), as well as hyaluronic acid plus amino acids (Aminogam, Errekappa), until suture removal. Sutures were removed after 14 days. Patient was followed up every 4 weeks until re-entry.



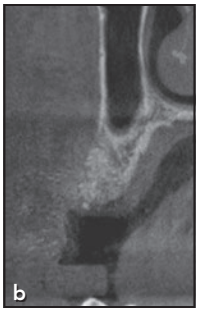


Fig 8 (a) *Intraoral radiograph after 5 months of healing. The lamina dura is no longer visible, and the former dentin graft has the same appearance of the surrounding bone tissue.* (b) *Cone beam computed tomography evaluation after 5 months of healing. The buccal plate has been resorbed, and the marginal ridge remodeling has been compensated by the ridge preservation procedure.*

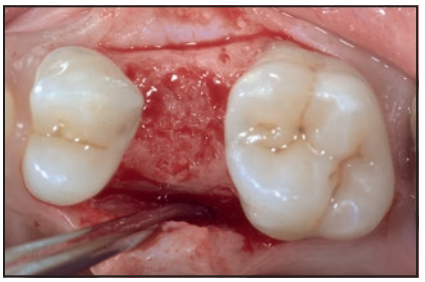
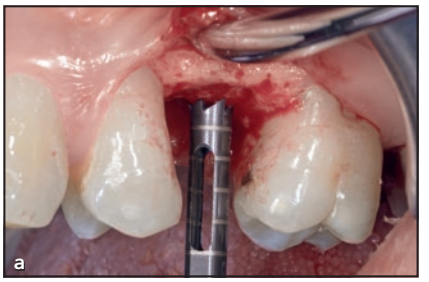


Fig 9 *After flap elevation, a newly formed hard tissue can be noted at the top of the former alveolus.*



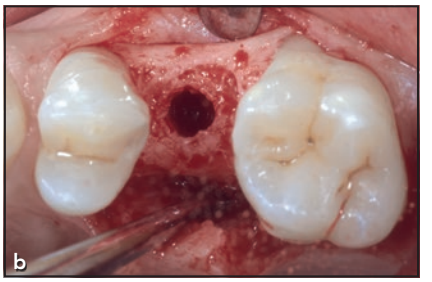


Fig 10 (a) *A bone trephine is used to harvest a biopsy sample in the exact area previously grafted with dentin particles.* (b) *This sampled area corresponds with the previous site preparation.*

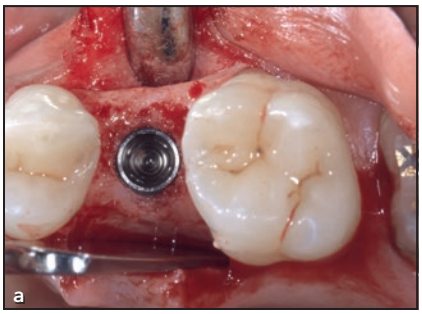
Twenty-four weeks after extraction, implant placement was planned. The soft tissue appeared completely healed (Fig 7) with preserved original ridge volume. Before implant surgery, a control intramural radiograph (Fig 8a) and CBCT (Fig 8b) were performed using the same specifications as at baseline. Under local anesthesia, a full-thickness flap was elevated (Fig 9) and, in the area corresponding to future implant insertion, a bone core was harvested from the grafted site using a 2-mm diameter trephine (Fig 10). Subsequently, the implant osteotomy was completed and a conical-shaped implant (4.1 × 12 mm) was inserted (BLT SLActive, Straumann) (Fig 11a). A healing abutment was directly screwed on top of the implant to pursue a transmucosal healing. After 4 weeks an impression was taken at the implant level, and after 2 more weeks a screw-retained provisional crown was delivered. Two months later, a screw-retained ceramic definitive crown was fabricated and inserted.

The core sample was prepared to be ground into nondemineralized sections according to the technique of Donath and Breuner.[18] The specimen was dehydrated in a graded series of ethanol using a system that involved agitation and vacuuming. The block was infiltrated with Technovit 7200 VLC-resin (Kulzer). The infiltrated specimen was placed into an embedding mold, and polymerization was performed under blue and white light. The polymerized block was cut longitudinally on an Exakt cutting unit (Norderstedt). The slice was reduced by microgrinding and polishing to an even thickness of 30 to 40 µm using an Exakt grinding unit. The section was stained with Sanderson's rapid bone stain and counterstained with acid fuchsin (Dorn & Hart, Loxley). Finally, the section was evaluated using both a Leica 205 stereomicroscope and a Leica DM6 B light microscope. Quantitative analysis of new bone formation was done with IMS software (Imagic).

Results

Clinical Evaluation

Following tooth extraction and ridge preservation with the dentin particles, healing was uneventful. Soft tissues were completely closed after 2 weeks and were mature and stable after 24 weeks.



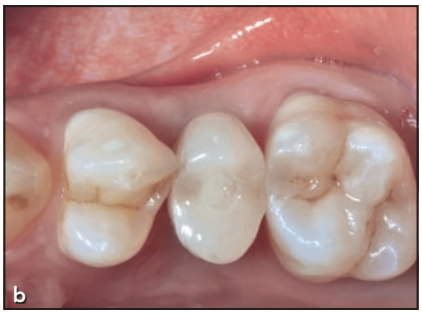


Fig 11 (a) *An osseointegrated implant is inserted in the preserved socket.* (b) *Final evaluation with the ceramic crown in place 1 year after implant placement.*

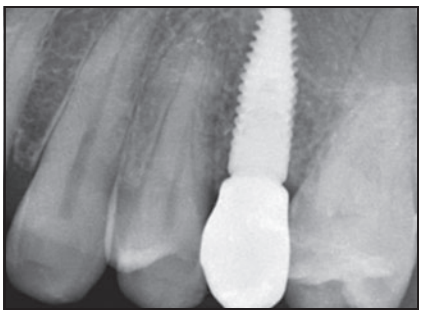


Fig 12 *Intraoral radiograph 1 year after implant placement showing stability of marginal bone levels.*

At the day of implant placement, after flap elevation, the socket was completely filled with hard bone-like tissue. After harvesting the bone biopsy sample, the implant site was prepared following the implant system specifications. An insertion torque of 35 Ncm was reached, with the curve of implant stability rising from the beginning to the end of placement. The implant successfully osseointegrated and was correctly loaded and prosthetically rehabilitated after 6 weeks. Soft tissues positively adapted to the new emergence profile, and the soft tissue contour created a physiologic anatomy at both the mesial and distal papillae and at the midfacial mucosa. The 12-month evaluation shows a perfect integration of the crown in the surrounding soft tissues (Fig 11b).

Intraoral Radiologic Evaluation

The intraoral radiographs show the compromised tooth at baseline and the postextraction socket filled with the dentin graft. After 24 weeks of healing, the lamina dura completely disappeared and the area previously grafted with the dentin particles acquired the same appearance of the surrounding bone tissue. The implant fixture was inserted at the bone level, and the 12-month evaluation shows stability of marginal bone levels (Fig 12).

Three-Dimensional Radiologic Evaluation

After tooth extraction and socket grafting, the CBCT scan shows a thin buccal plate and the alveolus accurately filled with the dentin graft. The horizontal dimension was 9.1 mm at the crestal level and was 9.5 mm at 3 mm apical to the crest.

The CBCT scan performed after 24 weeks revealed preservation of the ridge. The buccal bone plate was resorbed, but the dentin graft was able to compensate for marginal bone remodeling. The previous socket appeared to be completely filled with new mineralized tissue (Fig 8b). The horizontal dimension was 7.8 mm at the crestal level and was 8.6 mm at 3 mm apical to the crest.

Histologic Evaluation

The overview section of the bone core shows root fragments surrounded partially or completely by newly formed bone (Fig 13). Newly formed bone bridges the single root fragments. The spaces between root fragments and bone are filled with connective tissue. No inflammatory reaction is evident. When examining a cone cross-section of the biopsy sample, the connective tissue is evident, indicating that physiologic bone remodeling is occurring and affects both root fragments and bone. The root fragments contain both dentin and cementum areas. Newly formed bone has evident intimate contact with both dentin and cementum (Fig 14a). Newly formed bone areas along dentin fragments show osteocytes in the bone. At the bone surface, an osteoid layer and bone-forming osteoblasts are evident, indicating ongoing bone formation (Fig 14b).

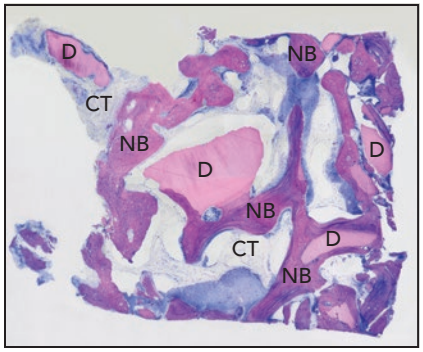


Fig 13 *Histologic image of the core showing the presence of connective tissue (CT) and the formation of new bone (NB) in direct contact with dentin (D) particles.*

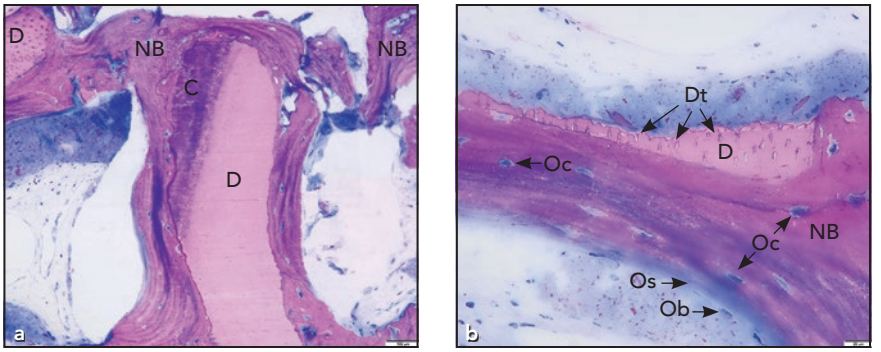


Fig 14 (a) *Ground section showing intimate contact between new bone (NB), dentin (D), and cementum (C).* (b) *Higher magnification revealing the ongoing bone formation with the presence of osteocytes (Oc) and osteoblasts (Ob) on the osteoid tissue (Os). New bone is in intimate contact with dentin and its tubules (Dt).*

Discussion

The goal of this case report was to describe the success of ground dentin (harvested from an extracted tooth) used for bone construction to prepare for implant placement in the patient. The clinical re-entry at 24 weeks revealed that the graft was incorporated and formed new bone in the extraction socket. The ridge volume was preserved, allowing for successful implant placement with good primary stability and without the need for additional bone augmentation. Soft tissues also healed properly, without any sign of inflammation. These positive findings corroborate the outcomes following the use of teeth as grafting biomaterials.

From a clinical point of view, extracted teeth can be used for grafting purposes both as blocks or particles. Extracted tooth roots have been used as blocks for lateral alveolar ridge augmentation in experimental studies, revealing a structural and biologic potential to serve as an alternative autograft to autogenous bone, capable of leading implant osseointegration.[19–21] More recently, it has been shown that this surgical concept can be used for ridge augmentation of extracted teeth in patients.[22,23]

Additionally, dentin particulate has been used as graft material to regenerate bone defects. Preclinical studies showed positive outcomes when tooth particles extracted from dogs' teeth were grafted immediately into the fresh sockets. As the dentin graft maintains the collagen structure, it seems able to preserve both the height and width of bone crests, suggesting that tooth particle graft can be viewed as a useful autogenous biomaterial for socket preservation[16] and ridge augmentation.[24]

The potential for using teeth particles as a bone graft material for jawbone formation was also measured using real-time polymerase chain reaction, microcomputer tomography, and histologic analysis in rats, reporting interesting outcomes.[15]

In humans, the clinical application of crushed granules of teeth mainly focused on the regeneration of several bone defect types and the preservation of alveolar bone.[17] Autogenous teeth grafted as particles seem to undergo gradual resorption and replacement by new bone of excellent quality through osteoinduction and osteoconduction,[25] leading to good implant primary stability and stability of marginal bone level.[26]

Conclusions

The present clinical case report demonstrates proof-of-concept that extracted tooth particles to be used as an autograft for bone regeneration in osseous defects have a clinical and biologic significance, with successful staged placement of osseointegrated implants.

Acknowledgments

The authors report no conflicts of interest.

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