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# The Use of Biphasic Calcium Sulfate (Bond Apatite®) for Surgical Treatment of Osseous Defects Resulting from Radicular Cysts – Clinical Study of 6 Months Follow-up

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**Abstract**

Surgical treatment of odontogenic cysts of the jaws accounts for a significant percentage of dental surgery procedures. Additionally, a wide range of procedures and augmentation materials are used in the reconstruction of these osseous defects. The authors present a study including histology of surgical treatment of odontogenic cysts using a Biphasic Calcium Sulfate composite bone graft cement (Bond Apatite®).

**Keywords:** *Bone regeneration, osseous defect, reconstructive techniques, radicular cyst*

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## Introduction

It has been estimated that radicular cysts may constitute on average 40%–80% of pathological lesions in the maxilla and mandible of the general population.[1-5] A large number of patients with confirmed odontogenic cysts are treated surgically to remove those identified radicular cysts. There are various procedures, such as decompression, marsupialization, and of course enucleation that require the use of various biomaterials for the reconstruction of the resulting osseous defect. Reconstructive techniques may present different levels of required technical skills. Those procedures requiring flap elevation/extension, using various membranes (resorbable and nonresorbable), pins or screws to fixate the membranes, and complicated suture techniques that often could be a challenge for the person performing the surgery. Intraoperative and postoperative complications may also result. Surgical procedures aim to minimize invasiveness and while maximizing the effectiveness for the patient. Therefore, the authors have attempted to assess the clinical efficacy of the Bond Apatite® material in the maxillary osseous defect regeneration following the surgical removal of the radicular cysts.

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## Materials and Methods

Thirty consecutive patients who were referred for planned oral surgery were then enrolled in the study. All patients had a clinical examination and standard radiographs confirming the initial diagnosis of an odontogenic cyst. The exclusion criteria included lack of patient consent for the use of Bond Apatite® preparation (Augma Biomaterials®). A control group of 30 patients was selected who were also treated for radicular cyst removal with reconstructive surgery using a deproteinized bovine bone grafts (xenograft). All surgical procedures were performed under local anesthetic (4% articaine with 1:200,000 epi) or IV sedation.

In the study group, following flap elevation, trepanation holes were created, and the cyst was removed atraumatically, and then sent for histopathological examination. In addition, resection of the apical 3 mm

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of the affected root was performed or the roots were atraumatically extracted. Based on the previous experience, following root resection, a 3-mm retrograde root canal preparation was created, and a retrograde fill was placed with Mineral Trioxide Aggregate®. The residual osseous defect was then filled with Bond Apatite® graft material in accordance with the manufacturer's instructions. Bond Apatite® is composed of a biphasic calcium sulfate and synthetic hydroxyapatite granules. The material consists of microneedle-shaped crystals of calcium sulfate and macrohydroxyapatite grains. When the graft is activated, there is a strong reaction between hydroxyapatite and calcium sulfate. This graft material goes through setting as it encounters saline and setting results within a few minutes, resulting in a cement-like material.

The wound site closure was performed without periosteum cutting to allow stretching of the flap to attempt primary site closure in the study group. Within the control group, primary wound closure was achieved to protect the xenograft material. Sites were fixated with the single sutures of resorbable (polydioxanone, a biodegradable synthetic polymer) or nonresorbable (nylon) sterile monofilament 4-0–6-0 sutures. The resorbable suture was on a round ½ circle needle, and the nonresorbable suture was on a reverse 3/8 circle-cutting needle. A total of 33 cysts were enucleated in the study group, including 28 root resections and 12 root extractions [Table 1].

A modified surgical procedure was performed in the control group, with various different types of graft placed into those osseous defects. Furthermore, the surgical technique included flap extension with periosteum cutting for a vertical-releasing incision and covering the grafted area with a collagen membrane prior to site closure. Several different graft materials were used and when the placement of deproteinized bovine bone particles (xenograft) was used it was mixed with either blood at the surgical site or use of platelet-rich fibrin. The membrane was stabilized with titanium pins. A total of 31 cyst enucleations were carried out, with 42 root extractions [Tables 2 and 3].

All surgical patients received an antibiotic, clindamycin with a loading dose of 1.2 g/os was administered 2 h before surgery and followed by 7 days oral administration due to the underlying pathology necessitating surgery. Patients were also prescribed a nonsteroidal anti-inflammatory drug (ketoprofen or paracetamol). Local status of the surgical area was evaluated at recall postsurgically using a three-point scale: (0) wound healing and maintaining sutures proceeds correctly; I°-wound dehiscence up to 10 mm without second inflammatory features, use of local pharmacology; and II°-wound dehiscence

**Table 1: Patient characteristics of the study group (*n*=30)**

| Quantity of patients | *n* |
|---|---|
| Age (years) | 28-68 |
| Mean age (years) | 55.6 |
| Sex | |
| Female/male | 16/14 |
| Range of diameter of the cyst minimum/maximum (mm) | 9-35 |
| Mean (mm) | 13.8 |
| Topography maxilla/mandible | 19/14 |
| Front segment of the maxilla | 10 |
| Lateral segment of the maxilla | 9 |
| Front segment of the mandible | 3 |
| Lateral segment of the mandible | 11 |
| Resection of the root | 28 |
| Extraction of the root | 12 |
| Quantity of graft using (cc) | 40 |

**Table 2: Patient characteristics of the control group (*n*=30)**

| Quantity of patients | *n* |
|---|---|
| Age (years) | 27-65 |
| Mean age (years) | 61.1 |
| Sex | |
| Female/male | 16/14 |
| Range of diameter of the cyst min/max (mm) | 10-40 |
| Mean (mm) | 14.6 |
| Topography maxilla/mandible | 17/14 |
| Front segment of the maxilla | 12 |
| Lateral segment of the maxilla | 5 |
| Front segment of the mandible | 7 |
| Lateral segment of the mandible | 7 |
| Extraction of the root | 42 |
| Quantity of graft using(cc) | 47 |

over 10 mm and exhibits second inflammatory features, leaving the wound-healed by granulation or need for additional surgery and removal of the graft. Discomfort and postoperative pain were tested using the Visual Analog Scale (100 mm long by a 0 mm means no pain and 100 mm the strongest possible pain). Control visits were carried out at 1, 3, 5, and 7 day postsurgically. Sutures were removed at 7 days postsurgery. Control radiographs were performed at the 7th day, 3 months, and 6 months after surgical treatment.

## Results

In 29 patients, 96.6% (16 women and 13 men) complete wound healing and suture maintenance was reported. In 1 case, 3.4% (1 men) a postoperative wound dehiscence (I°) occurred on day 5, which was allowed to heal by granulation (secondary intention) and was supported by local pharmacology utilizing chlorhexidine rinses three times daily. The wound closed after 3 weeks without any graft loss.

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**Table 3: Grafts used in the control group**

| Type | Sum of cases | Maxilla | Mandible | Quantity of graft(cc) |
|---|---|---|---|---|
| Putty®Osteobiol®[a] | 10 | 6 | 4 | 12 |
| MP3®Osteobiol®[b] | 7 | 8 | 9 | 10 |
| Gen-os® Osteobiol®[c] | 10 | 4 | 6 | 15 |
| Cerabone®Botiss Dental®[d] | 3 | 1 | 2 | 10 |

[a]heterologous <80% >300 micron prehydrated bone in a collagen gel, [b]heterologous 600-1000 µ prehydrated corticocancellous granules in a collagen gel, [c]autogenous bone, [d]xenograft

In the control group, of 24 patients, 80% (14 women and 10 men) no wounds dehiscences were observed. However, in 4 cases, 12% (2 men and 2 women), a wound dehiscence (I°) occurred on day 3 and 5, which was left to heal by granulation and was supported by local pharmacology for the subsequent 3 weeks. The wounds also closed after 2–3 weeks without loss of the graft material. In 2 cases, 8% (2 men), IIº wound dehiscence over 10 mm with secondary inflammatory features were observed. In both of these cases, it was necessary to remove the graft. In the assessment of postoperative discomfort and pain, VAS values in the range of 20–40 mm (mean 33) were recorded (1–3 day after surgery), whereas in the control group, the values given by the patients were a little bit higher in the range of 30–60 mm (mean 42), 1–7 day after the surgery.

Moreover, at day 7, 3- and 6-month radiographic images showed normal osseous remodeling and graft consolidation in the study group. Furthermore, in the control group, osseous tissue remodeling was slightly slower when examined radiographically at day 7 and 3 and 6 months.

The question has been what happens to the Bond Apatite® graft material, and it is replaced by host bone over time. Histologically, the specimen in the study group found that over time the particles of Bond Apatite® resorbed and were replaced with new young bone. Samples examined at 3 months found that at × 100 some residual particles of Bond Apatite® remained (dark areas), but they were connected to active bone (dark purple spots) with an absence if inflammatory reaction [Figure 1]. H and E staining of the histological samples clearly demonstrates new bone in contact with the residual Bond Apatite® particles [Figure 2].

At higher magnification (200×), a lack of inflammatory cells was noted with direct contact between the new bone and Bond Apatite® residual particles remaining [Figure 3]. At 6 months postsurgery, an immunohistochemical CD 68 study, which is a surface antigen used for the detection of bone cells, demonstrated active osteoblasts in the grafted osseous tissue, with little remaining Bond Apatite® (green) [Figure 4]. This supports prior reported studies that although Bond

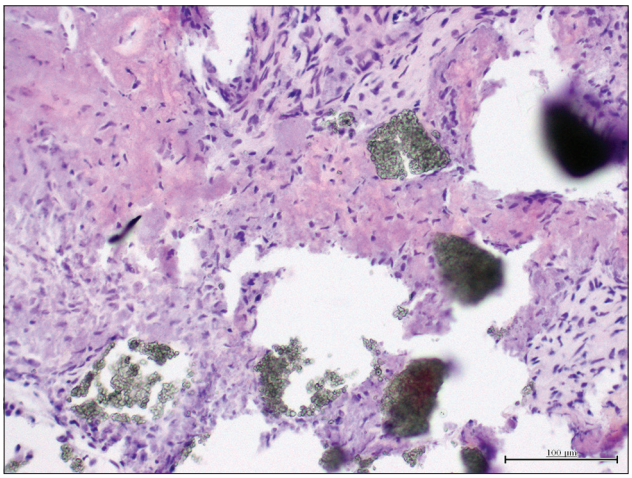


**Figure 1:** histology after 3 months shown at 100× with visible new young bone formulation (dark purple spots) and residual Bond Apatite (dark areas) that is converting to the bone with the absence of an inflammatory reaction

Apatite® forms a cement-like material upon setting, the graft material is replaced over several months with new active bone that contains osteoblasts with few particles remaining at about 6 months.

## Case example

A 40-year-old healthy male presented with a cyst in the anterior mandible with a fistula present. The patient reported daily pain and discomfort. A periapical radiograph demonstrated a large osseous defect associated with two failing endodontically treated teeth. Both teeth presented with insufficient obturation leading to the lesion and subsequent fistula [Figure 5]. A cone-beam computed tomography (CBCT) was taken which demonstrated the loss of a large area of the facial plate of the anterior mandible related to the ongoing enlargement of the cyst [Figure 6]. The axial slice of the CBCT demonstrated the destruction and loss of the facial plate at the large cyst [Figure 7].

Following flap elevation to expose the cyst, the cyst was enucleated and sent for histopathological examination. The apical of both teeth was resected, and a retro preparation was made and filled with MTA in both root apexes [Figure 8]. Bond Apatite® was activated within its syringe, and the defect was filled with approximately 1 cc of the graft material, filling the defect to the facial

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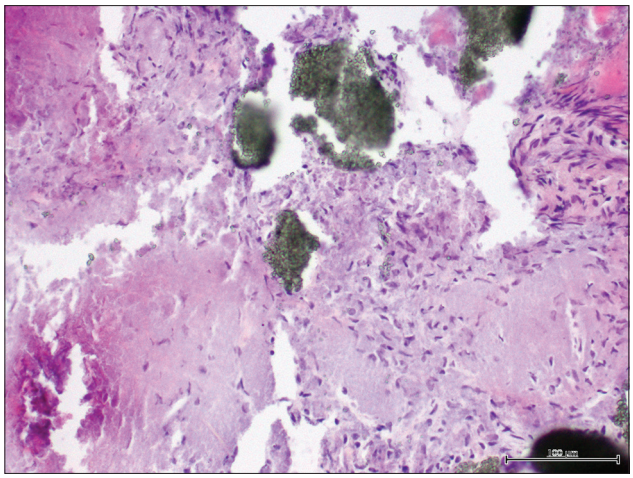

**Figure 2:** Another histology sample with H and E staining at 100× demonstrating Bond Apatite (dark areas) and new bone (dark-purple spots)

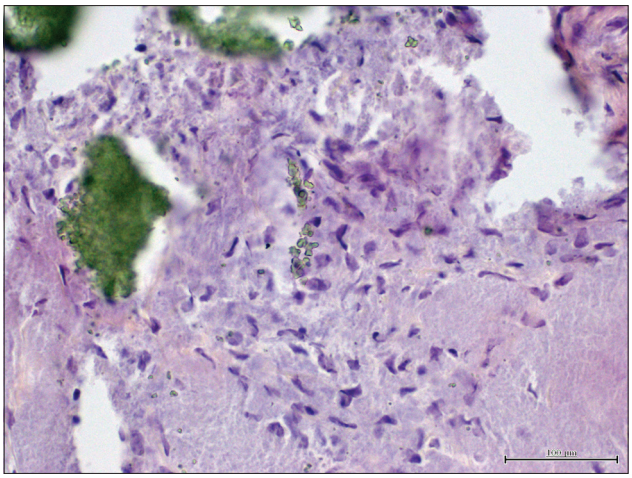

**Figure 3:** at higher magnification (×200), new bone (dark-purple spots) and residual Bond Apatite (green areas) is observed without any noted inflammatory cells present

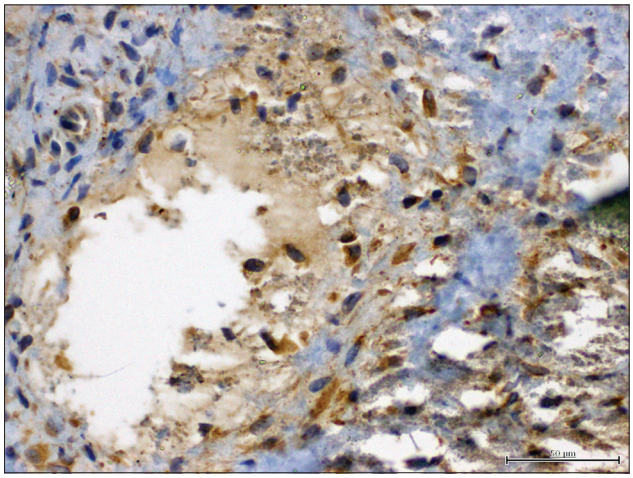

**Figure 4:** immunohistochemical study CD 68, a surface antigen used for the detection of bone cells, demonstrates active osteoblasts in the tissue, and little remaining Bond Apatite® (green)

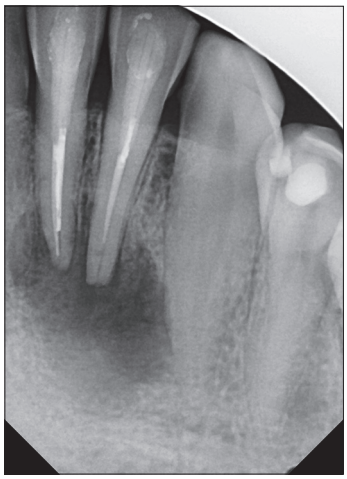

**Figure 5:** periapical radiograph with the lesion associated with prior endodontic treatment on the left mandibular lateral and central incisors

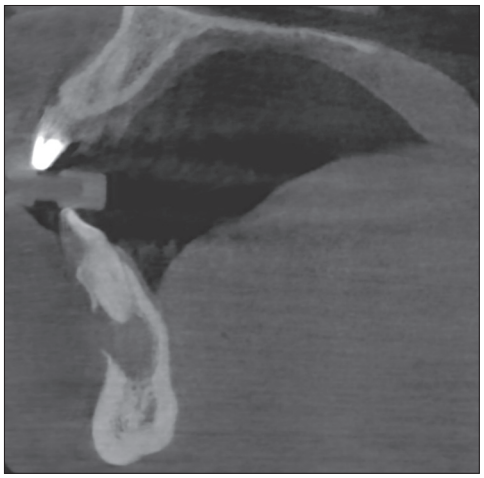

**Figure 6:** cone-beam computed tomography cross section demonstrating the size of the odontogenic cyst associated with the failing endodontic teeth in the mandibular anterior, with a lack of the facial plate noted

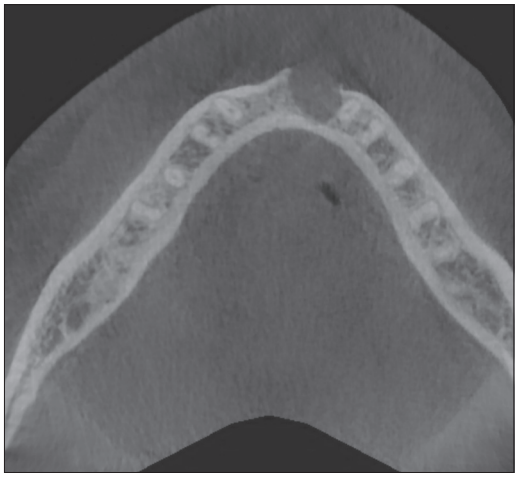

**Figure 7:** cone-beam computed tomography axial slice demonstration destruction of the facial plate related to the odontogenic cyst present

contour of the adjacent unaffected bone [Figure 9]. The flap was closed and sutures placed. A periapical radiograph was taken to document the apical retro fillings and defect filled with graft material [Figure 10].

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The patient returned at 7 days postsurgery for suture removal, and a CBCT was taken. The cross-section view demonstrated the defect to be filled with graft material, and the contour had been restored [Figure 11]. Reevaluation at 3 months postsurgery demonstrated on a periapical radiograph a blending of the graft material and new bone replacing it [Figure 12]. At the 6-month evaluation, a new CBCT cross section that the facial contour remained with the adjacent unaffected bone and the graft was replaced with bone similar in radiographic appearance to the native bone [Figure 13]. The axial slice view demonstrated the reconstruction of the prior lost facial plate with the replacement with new host bone [Figure 14].

## Discussion

This study demonstrates that using Bond Apatite® preparation in the group treated with odontogenic cysts is safe and effective in this cohort of patients. In addition, clinical efficacy is comparable to other osseous grafts in the control group. Various biomaterials are used in the procedures for the reconstruction of the maxilla and mandible. However, the biochemical structure of the Bond Apatite® and its simple application procedure minimizes the risk of secondary wound infection and graft loss.[6,7]

Similarly to our study, Baranes and Kurtzman have also reported good clinical effectiveness of Bond Apatite® in various jaw bone defects.They recommended that Bond Apatite® provides added benefits clinically. The current findings are comparable to those reported by Turri and Dahlin in an experimental study in rabbits.[9] The aim of their study was to histologically compare the dynamics of bone healing with calcium sulfate and deproteinized bovine bone in 18 rabbit maxilla's with healing evaluated at 2, 4, and 8 weeks by histology. They reported that the group with calcium sulfate demonstrated significantly more bone regeneration at all healing periods compared to the bovine bone group. Moreover, the authors concluded that calcium sulfate in combination with an extracellular matrix membrane provided synergistic effects of bone regeneration, seemingly due to stimulating angiogenesis in the early healing process.

Furthermore, Schindler *et al*. a clinical study was reported using calcium sulfate combined with hydroxyapatite in the orthopedic surgery presented by[10] Wherein, 13 patients were treated due to large aneurysmal bone cysts (6 cases) and giant cell tumors (7 cases) located in the epi- or metaphyseal areas of the lower limbs. According to the authors, composite bioceramic osteoconductive grafts, which combine porous hydroxyapatite with calcium sulfate, provided a framework for human osteogenesis and avoid donor-site

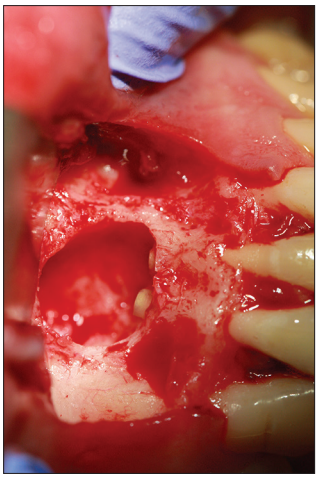

**Figure 8:** size of the defect following the enucleation of the odontogenic cyst, root resection, and retrograde filling

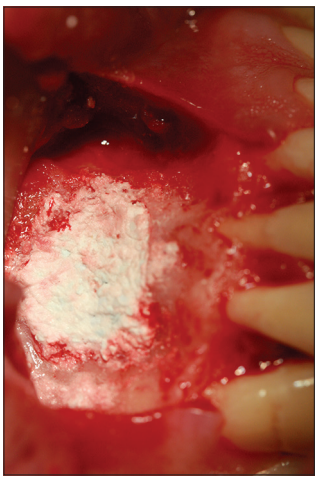

**Figure 9:** bond Apatite® placement to fill the large osseous defect

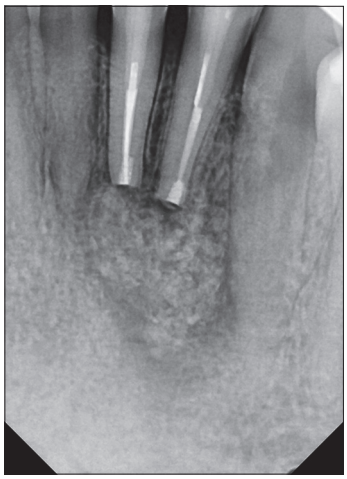

**Figure 10:** periapical radiograph immediately following the surgery to document the retrograde fillings in the two roots and fill of the defect with Bond Apatite®

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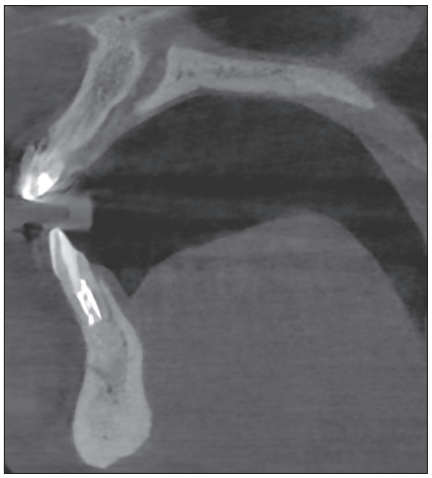

**Figure 11:** cone-beam computed tomography cross section at 7 days postsurgery to document the fill of the defect and restoration of the osseous contour of the facial plate with the graft placement

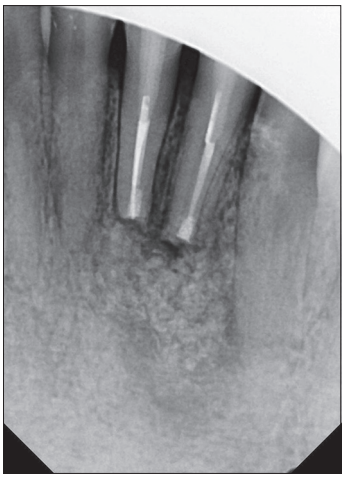

**Figure 12:** periapical radiograph at 3 months postsurgery

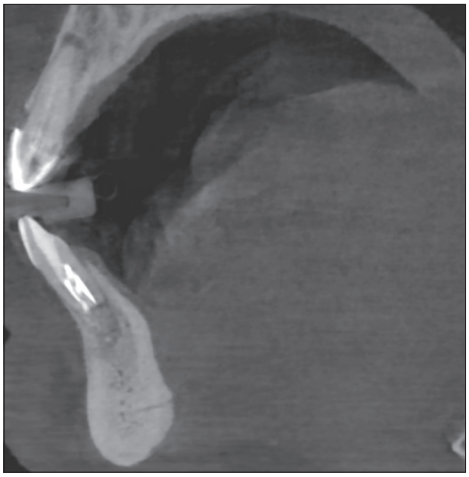

**Figure 13:** cone-beam computed tomography cross section at 6 months demonstrating the replacement of the Bond Apatite® with new-host bone maintaining the facial contour of the mandible that was affected by the lesion that was removed

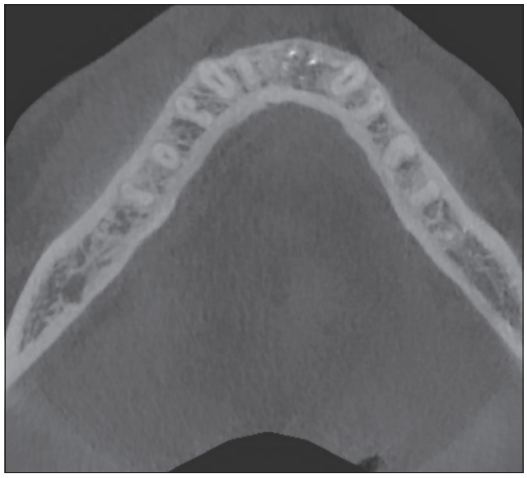

**Figure 14:** cone-beam computed tomography axial view demonstrating at 6 months the facial contours have been restored by osseous grafting of the large defect with Bond Apatite®

morbidity, frequently found with autologous bone graft harvesting.

## Conclusion

The data presented in this study and a few previous reports support the continuation of use of Bond Apatite® formulation for reconstructive oral surgery procedures. Such use reduces the time and cost of osseous grafting of the resulting defect but also increases patient comfort related to the elimination of flap mobilization that would be required with wound closure by primary intention. Moreover, the use of biphasic calcium sulfate combined with hydroxyapatite preserves the overall goal to maintain the shape of the osseous contours following cyst enucleation in those patients. As demonstrated by our observations, mastering local inflammatory complications is most effective in an outpatient setting. In addition, the widespread use of such materials in other areas of surgery, such as in orthopedics, also speaks for the use of Bond Apatite® graft in the reconstruction of large bone defects.

Finally, the use of the Bond Apatite® preparation is a simple, inexpensive, and effective reconstructive treatment of osseous defects after the enucleation of odontogenic cysts. With long-term observations of the study group, it might also be possible to evaluate the efficacy of the Bond Apatite® in the reconstruction of large osseous defects.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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