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# Mandibular Osteoblastoma: A Report of Two Cases Exploring the Use of Computer-Assisted Surgical Planning

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## Abstract

Osteoblastomas are benign bone tumors that may arise in the mandible. Because they share clinical and histologic features with other bone-forming lesions, diagnosis typically requires radiographic evaluation and biopsy. Treatment involves complete excision with adequate margins, often followed by reconstruction to restore local form and function. Advances in cone-beam CT (CBCT) and virtual surgical planning (VSP) now provide enhanced 3D visualization, facilitating accurate resection planning, fabrication of custom surgical guides, and precise reconstruction. These technologies are particularly valuable in complex mandibular cases in which preservation of occlusion and symmetry is critical. This study was conducted to determine the effectiveness of a computer-assisted approach using CBCT scans and surgical guides to plan the appropriate resection of mandibular osteoblastomas. This case report aims to present diagnostic methods and surgical treatment of mandibular osteoblastoma and highlight the clinical and histopathological features that aid in its identification. Two cases were thoroughly reviewed, with biopsy and histopathological examination performed by oral and maxillofacial pathologists. In addition, computer-assisted planning using a surgical guide was implemented to determine its effect on the surgical approach. The use of advanced imaging techniques and VSP has proven invaluable in accurately assessing tumor extent and planning precise surgical excision and reconstruction. The combination of computer-assisted planning with appropriate surgical biopsy and histopathological examination has allowed for meticulous preoperative visualization and accurate planning, leading to a higher rate of surgical success and a reduced risk of recurrence. Long-term follow-up is essential to monitor for recurrence and ensure the overall health and function of the affected area. The cases presented demonstrate the efficacy of modern surgical techniques and highlight the importance of multidisciplinary collaboration in the treatment of osteoblastomas.

**Categories:** Oral Medicine, Anatomy, Dentistry
**Keywords:** cone-beam computed tomography (cbct), mandible implants, mandible surgery, osteoblastoma of mandible, tumor of mandible

## Introduction

Osteoblastomas are rare primary bone tumors characterized by excess osteoblastic proliferation in compact or cancellous bone [1,2]. These tumors predominantly affect men, with a male-to-female ratio of 2:1. Approximately 90% of cases occur in individuals younger than 30 years, with an average age at presentation of 17 years [1,3]. The mandible, the largest bone in the human skull, forms the lower jawline, articulates with the maxilla for mastication, and serves as an insertion point for several muscles of facial expression [4]. Although osteoblastomas more commonly arise in the long bones, spine, and sacrum, they affect the maxillofacial skeleton in 10-15% of cases [1,2,5,6]. They preferentially develop in the mandible rather than the maxilla and account for 1% of all bone tumors and 3% of all benign bone tumors [1,7]. As a relatively rare occurrence, osteoblastomas must be carefully diagnosed and treated.

An incisional biopsy and histopathological analysis are often employed to help differentiate these tumors from other bone-forming lesions, such as osteoid osteomas and osteosarcomas [8,9]. Surgical treatment can be accomplished through tumor excision and subsequent reconstruction, often with bone grafting and endosseous dental implants [9,10]. If teeth are involved with the tumor, extraction is often indicated [11]. Local excision or curettage is commonly used to treat osteoblastomas [12]. A recurrence rate of up to 20% has been attributed to the tumor's vascular nature, which often leads to incomplete excision and necessitates stringent intraoperative hemorrhage control [12]. Thus, larger osteoblastomas and those located in more difficult-to-access areas are best treated with wide-access peripheral resection with 5 mm margins [12]. The goals of treatment for osteoblastomas are to preserve dental occlusion, masticatory function, and facial symmetry [13]. Although benign, osteoblastomas may be aggressive, necessitating efficient detection and early diagnosis to avoid invasive surgery and malignant transformation [13,14].

## Clinical, histologic, and radiographic features

Osteoblastomas are histopathologically similar to osteoid osteomas, comparatively common benign bone-forming neoplasms that are rarely found in the maxillofacial region [3]. Because of this similarity, lesion size and symptomatology are clinically assessed to help differentiate the two [15]. Histopathological assessment of a biopsy specimen by an experienced oral pathologist is crucial for accurate diagnosis. Local pain and swelling are present in approximately 75% of facial osteoblastoma cases [15]. However, unlike in cases of osteoid osteoma, the pain does not occur at night and is typically not relieved by nonsteroidal anti-inflammatory drug therapy [16]. The palpable mass and pain may worsen over the course of months, often without changes in occlusion or range of motion [3,14]. Notably, pain caused by osteoblastomas typically does not present nocturnally [16].

On histological examination, osteoblastomas demonstrate osteoblastic proliferation along newly formed bony trabeculae set in a loose, edematous fibrovascular stroma. The bony trabeculae exhibit varying degrees of mineralization and may occasionally display a lace-like pattern. Prominent osteoblastic rimming and osteoclast-type multinucleated giant cells are typically present [17]. Although the tumors may appear well-delineated on gross examination, they can microscopically fuse with normal bone or extend into soft tissue. Typical mitotic figures may be observed, but atypical ones are not seen [17].

Radiologic evaluation is another component of diagnosis. Osteoblastomas typically appear as round or elliptical radiolucent lesions that may be well- or ill-defined [15,18]. Some lesions display a calcified plaque in the radiolucent area and a corticated border, indicating substantial calcification [15,18]. Although these characteristics are often shared with osteoid osteomas, the latter typically display a larger area of sclerotic bone formation and a central region of lucency known as the nidus [3].

## Diagnosis and treatment

Diagnosis of an osteoblastoma is achieved through clinical, radiological, and histological evaluation. An incisional or excisional biopsy may be performed to obtain the sample necessary for histopathological analysis [14,18]. Although invasive diagnostic surgery is typically not necessary, excisional biopsies may be considered in cases in which the tumor is rapidly enlarging and excessively painful or when radiologic screening is suggestive of osteosarcoma [17,18].

Osteoblastomas can be treated with complete en bloc surgical excision or more conservative options, such as curettage, which is commonly practiced despite its association with a relatively high recurrence rate [14,17,18]. For more extensive resection procedures, bone grafting and dental implant replacement of missing teeth are viable treatments to restore the patient's form and function [9]. Moshref et al. described autologous grafting of iliac bone to the surgical defect, followed by endosseous dental implant placement four months later [9]. Another report described reconstruction using an autologous costochondral graft and endosseous dental implants following tumor excision and resection of the right mandible [10]. Our case series details computer-assisted planning and virtual surgical planning (VSP) of mandibular resection, grafting, and reconstruction using a custom titanium plate and bone grafting with a combination of cellular allograft and rhBMP-2, an osteoinductive protein.

## Outcomes, prognosis, and follow-up

Mild episodic pain and numbness at the surgical site have been reported following repair of the defect [11]. As osteoblastomas have a recurrence rate of up to 20%, complete tumor excision is preferred to minimize this risk. Additionally, osteoblastomas have been reported to undergo malignant transformation into osteosarcomas, making long-term follow-up crucial for all patients [19]. The risk of recurrence and likelihood of graft survival can be managed through longitudinal monitoring, which should include clinical and radiographic examinations [7,19].

## The computer-assisted approach

In recent years, computer guidance has been increasingly used in mandibular surgery to assist with extensive reconstructions. Computer-guided surgery utilizes 3D imaging data as a basis for VSP, allowing for 3D visualization of the surgical site rather than the traditional 2D approach, which can lead to more errors [20]. Originally indicated for bone defects following ablative tumor surgery, VSP is also used for reconstruction in cases involving infections, trauma, and congenital abnormalities [20].

Several imaging modalities are used to create a 3D map of a patient's defect, including CT and cone-beam CT (CBCT) scans, along with CT angiography to assess the vasculature [20]. Accuracy is ensured through high-resolution scans and slice increments of less than 1.0 mm, which are used to generate a dataset that is imported into 3D planning software to define anatomical and pathological regions [20]. The software can then create physical models for complete visualization of the surgical site and allow additional datasets to be integrated and superimposed to create hybrid models [20].

We present two cases of mandibular osteoblastoma in which we utilized computer-assisted treatment

planning with VSP. These two cases were previously presented as a poster at the Asian Pacific American Medical Student Association (APAMSA) Region IV & IX Joint Conference on October 12, 2024, at Emory University School of Medicine, Atlanta, GA, USA.

## Case Presentation

### Case 1

A 17-year-old female patient presented with an anterior mandibular lesion discovered on radiographic examination. The patient underwent CBCT using TxStudio Software (DEXIS Imaging, Hatfield, PA, USA), which showed a nonhomogeneous, mixed-density anterior mandibular lesion in the region of teeth #22-27. There was no resorption or displacement of the roots of teeth #22-27. Bony expansion and thinning of the cortical plates were observed, with interruption of both the facial and lingual cortices (Figure *1*).

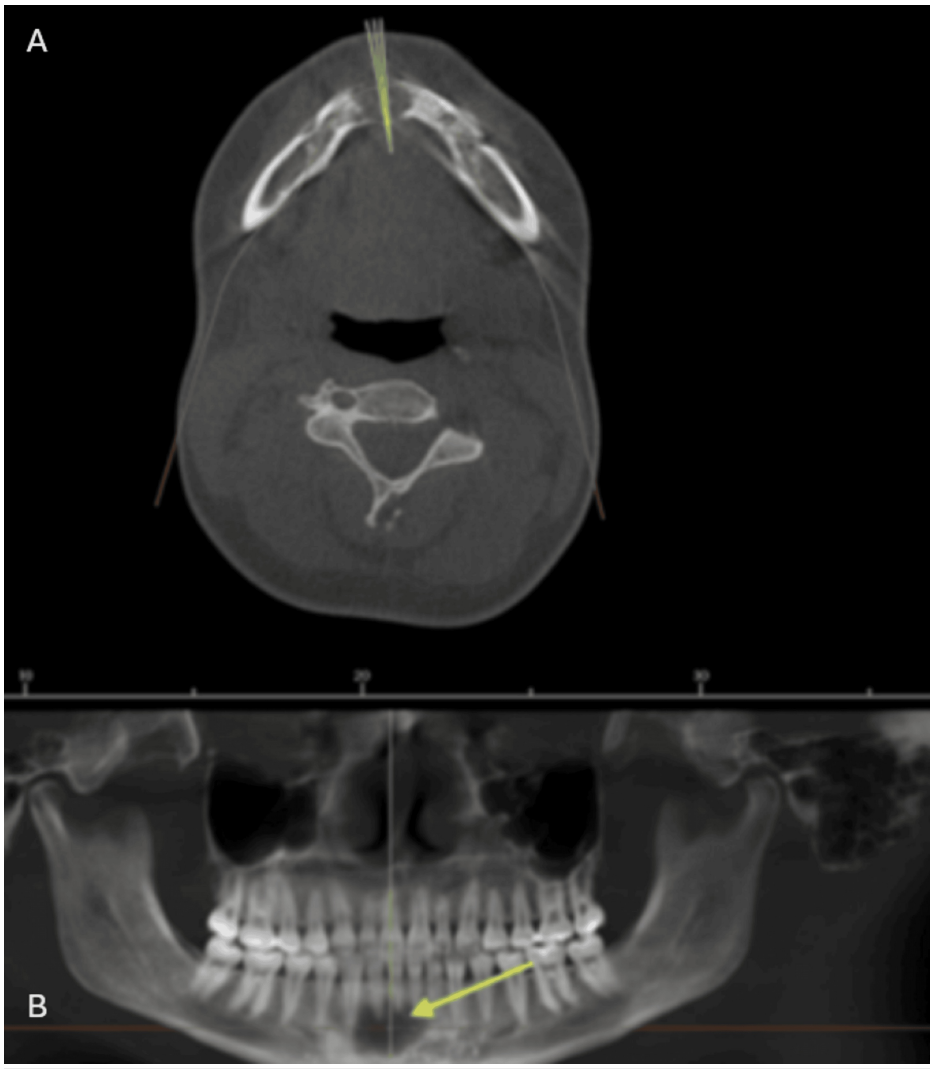



**FIGURE 1: Case 1: CBCT scan of the anterior and posterior lesion site of the mandible.**

(A) Superior and inferior views (horizontal plane) of the lesion (the yellow arrow indicates the pathological defect of the mandible). (B) Anterior and posterior views (panoramic view) of the mandibular lesion (the yellow arrow indicates the pathological defect of the mandible).

CBCT, cone-beam CT

Initial biopsy of the lesion revealed a benign fibro-osseous lesion, with a differential diagnosis that included cemento-osseous dysplasia, ossifying fibroma, and cemento-ossifying fibroma. After consultation with the patient and her mother, the decision was made to excise the lesion with 5 mm margins. VSP was utilized to plan the resection and reconstruction with a custom titanium plate. Imaging was displayed using Anatomage software (Anatomage Inc., San Jose, CA, USA). The virtual plan was presented to the patient and her mother

so that they could accurately visualize the planned resection and reconstruction (Figure 2).

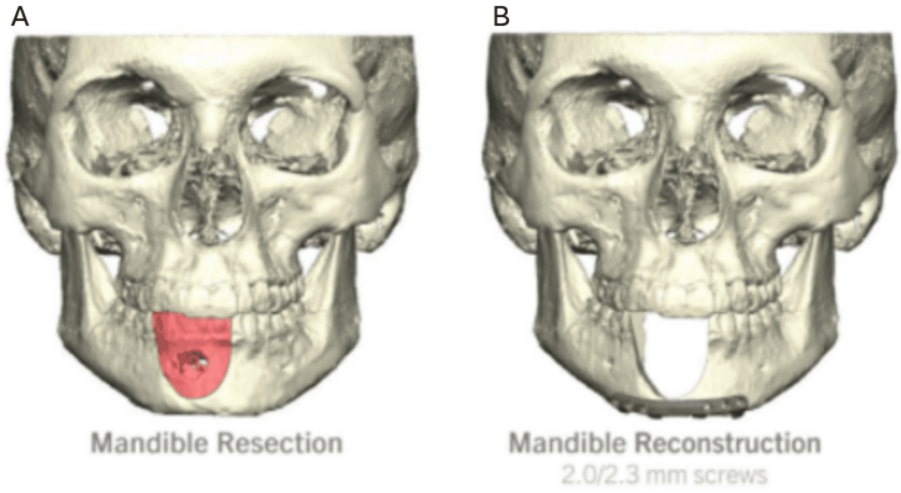



**FIGURE 2: Case 1: 3D-reconstructed CT scan of planned resection and reconstruction of the mandible.**

(A) The red section shows the boundary outlining the area of lesion removal. (B) The metal bar at the inferior border of the mandible shows the reconstructed portion of the mandible.

Grafting of the surgical defect was performed using resorbable osteosynthesis mesh (SonicWeld, KLS Martin, Jacksonville, FL, USA), cadaveric allograft (ViviGen Cellular Bone Matrix, LifeNet Health, Virginia Beach, VA, USA/DePuy Synthes, Raynham, MA, USA), and bone morphogenetic protein (BMP; Medtronic, Minneapolis, MN, USA). Histopathological evaluation of the excisional biopsy specimen revealed mandibular osteoblastoma.

The decalcified sections of the histopathological slides showed fragments of a tumor composed of irregularly shaped, often interconnecting, viable bone trabeculae demonstrating prominent osteoblastic rimming. The osteoblasts were triangular in shape and contained a perinuclear hof. Bridging of viable bone trabeculae by osteoblasts was readily identified. Numerous osteoclasts were also seen. The supporting stroma was loosely collagenized but markedly well-vascularized, with extravasated erythrocytes. The tumor was noted to be in continuity with the cortical bone.

Treatment included extensive reconstructive bone grafting of the anterior mandibular defect using resorbable osteosynthesis mesh (SonicWeld, KLS Martin), cadaveric allograft (ViviGen Cellular Bone Matrix, LifeNet Health/DePuy Synthes), and BMP (Medtronic). She has undergone treatment planning for staged endosseous dental implant replacement of her missing anterior teeth. There was no evidence of lesion recurrence at either the first or second postoperative visit. The first postoperative visit was one month after tumor resection, and the second was three months after tumor resection.

## Case 2

A 38-year-old female presented with a lesion of the left anterior mandible that was discovered on radiographic examination. A CBCT scan generated using TxStudio (DEXIS Imaging) revealed a well-defined, nonhomogeneous lesion (14.5 mm × 10 mm) apical to teeth #20-23 and extending into the interradicular regions. There was no displacement or resorption of the roots of teeth #20-23. The outer cortical plates were thinned, and the facial cortex was minimally expanded without cortical interruption (Figure 3). Biopsy of the lesion was diagnostic of osteoblastoma (Figure 4).

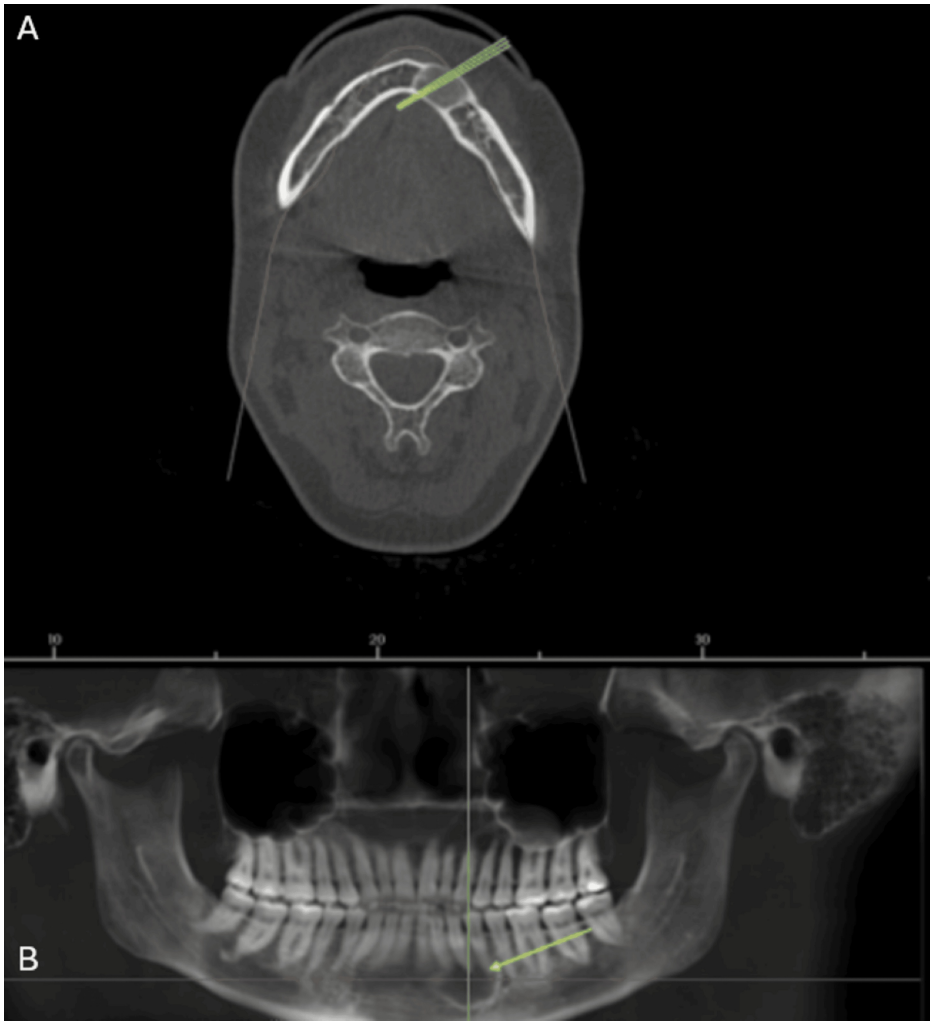



**FIGURE 3: Case 2: CBCT scan of the anterior and posterior lesion site of the mandible.**

(A) Superior and inferior views (horizontal plane) of the lesion (the yellow arrow indicates the pathological defect of the mandible). (B) Anterior and posterior views (panoramic view) of the mandibular lesion (the yellow arrow indicates the pathological defect of the mandible).

CBCT, cone-beam CT

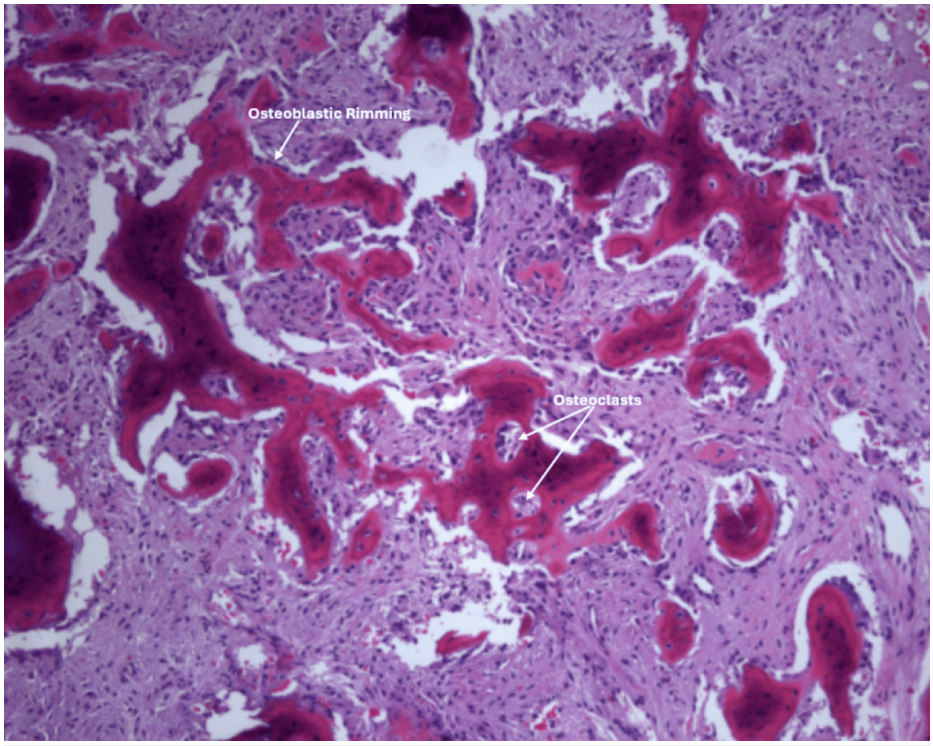



**FIGURE 4: Case 2: histopathologic biopsy of osteoblastoma (H&E, ×100).**

The histology image shows osteoblastic rimming and osteoclasts.

Histopathological examination of decalcified sections revealed a tumor composed of irregularly shaped osteoid trabeculae set in markedly well-vascularized, poorly collagenized fibrous connective tissue. The bone trabeculae were rimmed by plump, uniform osteoblasts and scattered multinucleated osteoclasts. VSP was performed, and the surgical plan was visualized and reviewed with the patient preoperatively. The patient was able to fully appreciate and understand the planned surgical resection with 5 mm margins, including the extraction of necessary teeth and reconstruction with a custom titanium reconstruction plate, using computer-assisted planning displayed with Anatomage software (Anatomage Inc.; Figures *5*, *6*).

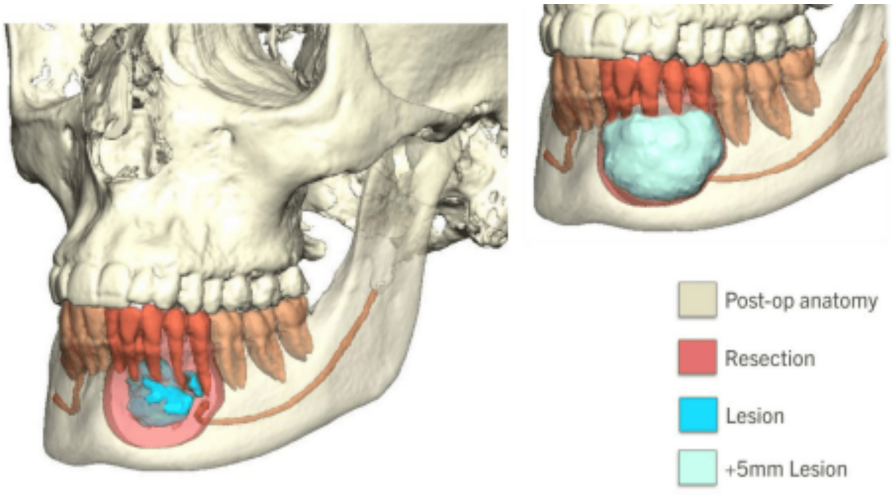



**FIGURE 5: Case 2: 3D-reconstructed CT scan of planned resection of the mandible.**

The resection is highlighted in red, and the lesion to be removed is highlighted in blue.

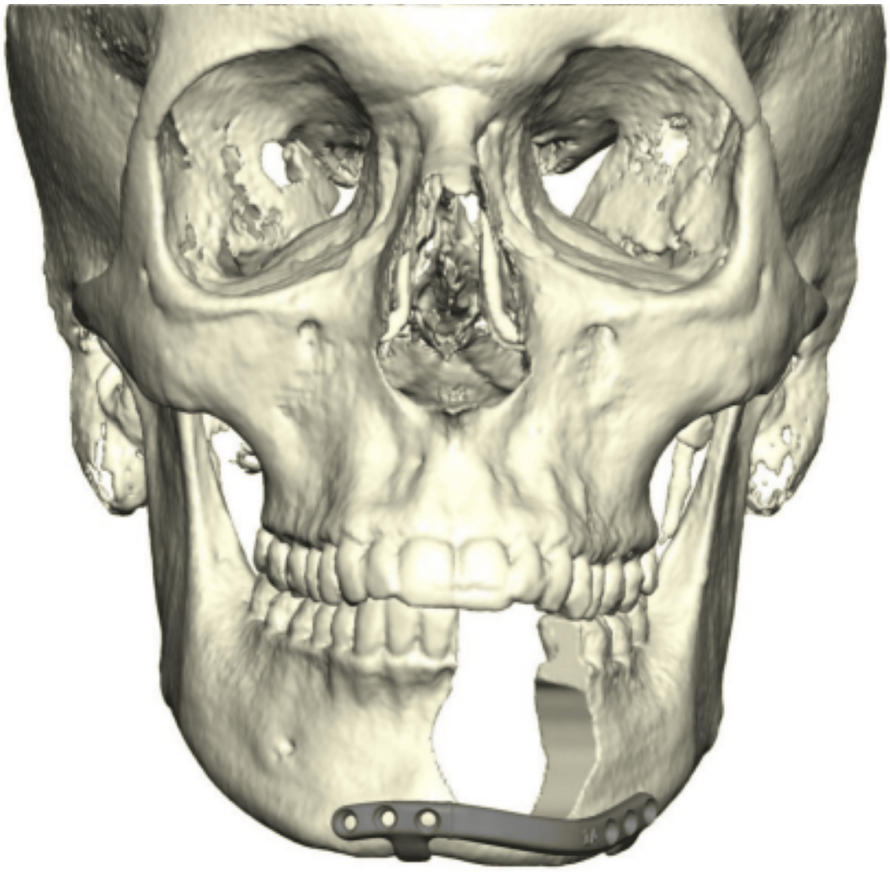


**FIGURE 6: Case 2: 3D-reconstructed CT scan of custom 2.0-mm-thick reconstruction plate and resection area.**

Treatment included extensive reconstructive bone grafting of the anterior mandibular defect using cadaveric bone and BMP-2. She underwent treatment planning for staged endosseous dental implant replacement of her missing anterior teeth. There was no evidence of lesion recurrence at either the first or second postoperative visit. The first postoperative visit was one month after tumor resection, and the second was three months after tumor resection.

The clinical and radiographic characteristics of both patients are summarized in Table *1*.

| Characteristics | Case 1 | Case 2 |
|---|---|---|
| Age | 17 years | 38 years |
| Site | Teeth #22-27 | Teeth #20-23 |
| Size | 15 mm × 10 mm | 14.5 mm × 10 mm |
| Radiographic features | Nonhomogeneous, mixed-density anterior mandibular lesion in the region of teeth #22-27. No resorption or displacement of the roots of teeth #22-27. Bony expansion and thinning of the cortical plates, with interruption of both facial and lingual cortices. | Nonhomogeneous lesion (14.5 mm × 10 mm) apical to teeth #20-23 and extending into the interradicular regions. No displacement or resorption of the roots of teeth #20-23. Thinning of the outer cortical plates, with minimal expansion of the facial cortex and no cortical interruption. |
| Biopsy result | Benign fibro-osseous lesion | Tumor composed of irregularly shaped osteoid trabeculae set in markedly well-vascularized, poorly collagenized fibrous connective tissue |
| Final diagnosis | Mandibular osteoblastoma | Mandibular osteoblastoma |
| Procedure | Excision of the lesion with 5 mm margins | Extraction of necessary teeth and reconstruction with a custom titanium reconstruction plate using computer-assisted planning |
| Graft | Grafting of the surgical defect using resorbable osteosynthesis mesh, cadaveric allograft (ViviGen Cellular Bone Matrix, LifeNet Health, Virginia Beach, VA, USA/DePuy Synthes, Raynham, MA, USA), and BMP (Medtronic, Minneapolis, MN, USA) | Extensive reconstructive bone grafting of the anterior mandibular defect using cadaveric bone and BMP-2 |
| Margins | 5 mm | 5 mm |
| Complications | None | None |
| Follow-up | No evidence of lesion recurrence at either the first or second postoperative visit. The first postoperative visit was one month after tumor resection, and the second was three months after tumor resection. | No evidence of lesion recurrence at either the first or second postoperative visit. The first postoperative visit was one month after tumor resection, and the second was three months after tumor resection. |

**TABLE 1: Comparison of clinical, radiographic, and treatment characteristics of Case 1 and Case 2.**

## Discussion

The cases presented in this paper highlight the importance of early diagnosis and treatment of mandibular osteoblastomas to prevent potential complications, such as recurrence and malignant transformation [13]. The use of advanced imaging techniques and VSP has proven invaluable in accurately assessing tumor extent and planning precise surgical excision and reconstruction.

Resection with reconstruction plate fixation was chosen rather than curettage because of the lesion's size, extent, and involvement of the surrounding bone, which raised concerns about residual disease and structural instability following curettage alone. Complete resection was therefore considered more appropriate to achieve adequate local control and reduce the risk of recurrence. Furthermore, reconstruction with a plate was necessary to restore the structural integrity of the affected bone and provide adequate mechanical stability.

Histopathological examination remains the gold standard for diagnosing osteoblastomas, as clinical and radiographic features alone may not be sufficient to differentiate them from other bone-forming lesions [14,18]. The aggressive nature of some osteoblastomas underscores the need for complete surgical excision with adequate margins to minimize the risk of recurrence [13,14].

Once appropriate histopathological examination has been performed and the margins for mandibular osteoblastoma resection have been determined, computer-assisted planning can be initiated [20]. This involves using CBCT scans with slice thicknesses of greater than 1.0 mm, along with surgical guides, to plan en bloc resection with 5 mm peripheral margins, thereby minimizing the risk of incomplete resection [19,20].

In the cases reported in this series, the combination of computer-assisted planning with appropriate surgical biopsy and histopathological examination has allowed for meticulous preoperative visualization and accurate planning, leading to a higher rate of surgical success and a reduced risk of recurrence [19]. In both cases, the virtual presentation increased patient appreciation and understanding of the indicated procedures. The integration of modern technology into surgical planning and execution, together with traditional diagnostic methods, has led to improved precision and treatment efficacy in complex cases such as mandibular osteoblastomas.

## Conclusions

Osteoblastomas, although rare, require prompt and accurate diagnosis followed by appropriate surgical intervention to ensure favorable outcomes. The combination of histopathological analysis, advanced imaging, and VSP provides a comprehensive approach to managing these tumors. Long-term follow-up is essential to monitor for recurrence and ensure the overall health and function of the affected area. The cases presented demonstrate the efficacy of modern surgical techniques and highlight the importance of multidisciplinary collaboration in the treatment of osteoblastomas.

## Additional Information

### Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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**Acquisition, analysis, or interpretation of data:** Ahmad Ahmadi, Jason Portnof, Leon Liu, Mullar I. Zakher, Renee Reich, Sandra Khuu

**Drafting of the manuscript:** Ahmad Ahmadi, Jason Portnof, Leon Liu, Mullar I. Zakher, Renee Reich, Sandra Khuu

**Critical review of the manuscript for important intellectual content:** Ahmad Ahmadi, Jason Portnof, Leon Liu, Mullar I. Zakher, Renee Reich, Sandra Khuu

**Supervision:** Ahmad Ahmadi

### Disclosures

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