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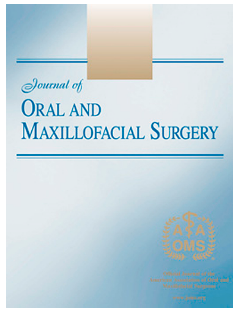

Skull base erosion resulting from primary tumors of the temporomandibular joint and skull base region: our classification and reconstruction experience

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Skull base erosion resulting from primary tumors of the temporomandibular joint and skull base region: our classification and reconstruction experience

Abstract

Objective: to introduce our classification and reconstruction protocol for skull base erosions in the temporomandibular joint and skull base (TMJ-SB) region. **Materials and Methods:** The patients with neoplasms in the TMJ-SB region treated from January 2006 to March 2017 were reviewed. Skull base erosion was classified into three types according to the size of the defect. **Results:** We included 33 patients, of whom 5 (15.2%) had type I defects (including 3 in whom free fat grafts were placed and 2 in whom deep temporal fascial fat flaps [DTFFF] were placed). Eight patients (24.2%) had type II defects, and all of the patients received DTFFFs. A total of 20 patients (60.6%) had type III defects, including 17 in whom autogenous bone grafts were placed, 1 in whom titanium mesh was placed, and 2 who received total alloplastic joints. The mean follow-up period was 50 months. All of the patients exhibited stable occlusion and good facial symmetry. No recurrence was noted. **Conclusion:** Our classification and reconstruction principles allowed reliable morpho-functional skull base reconstruction.

Keywords: skull base erosion, temporomandibular joint and skull base region, classification, reconstruction protocol, morpho-functional reconstruction

Skull base erosion resulting from primary tumors of the temporomandibular joint and skull base region: our classification and reconstruction experience

Introduction

Anatomically, the glenoid fossa of the temporomandibular joint (TMJ) is part of the temporal bone, separating the mandibular condyle from the middle cranial fossa. The glenoid fossa is always thin and translucent, with a roof thickness of 1.00±0.70 mm in Chinese subjects[1]. Due to the close relationship between the condyle and middle cranial fossa, the term "temporomandibular joint and skull base" (TMJ-SB) was been proposed to define this region [2]. Although TMJ pseudotumors and tumors are uncommen, some neoplasms such as synovial chondromatosis, pigmented villonodular synovitis, giant-cell tumors, eosinophilic granulomas, osteochondromas and other malignant tumors can invade the middle cranial fossa and erode the skull base [3-6]. In view of the esthetic and functional importance of the TMJ and potentially life-threatening complications such as cerebrospinal fluid (CSF) leakage, secondary meningitis, and/or cerebral trauma, bony reconstruction of the skull base is both important and challenging. Defects of different sizes require different methods of reconstruction. However, few reports have addressed differences in defect size in terms of appropriate bony reconstruction.

In this paper, we retrospectively reviewed the records of 33 patients with neoplasms in the TMJ-SB region, who were surgically treated from 2006 to 2017. Our classification of skull base erosions in the TMJ-SB region, and our reconstruction of each type erosion were discussed.

Patients and Methods

The TMJ-SB region is defined as follows: The superior boundary – is the temporal bone, the inferior boundary – is at the level of the mandibular lingula, the anterior boundary –is the posterior wall of the maxillary sinus, the posterior boundary – is the external auditory canal, the lateral boundary – is the skin, and the medial boundary –

is the foramen ovale and external lamina of the pterygoid process (Figure 1).

From January 2006 to March 2017, 518 patients with TMJ neoplasms were diagnosed and treated in the TMJ division of the Ninth People's Hospital affiliated with the Shanghai Jiao Tong University School of Medicine. After obtaining ethics approval from the clinical research committee of our hospital, we reviewed computed tomography (CT) data and magnetic resonance imaging (MRI) information on the TMJ-SB region, and the surgical records. We retrieved general patient information, histopathological diagnoses, skull base defect sizes, treatment methods, wound complications, and follow-up findings.

Classification of skull base erosions

Based on CT and MRI of the TMJ-SB region, skull base erosions were classified into three types by reference to defect size: type I, defect size less than one-third the size of the glenoid fossa (Figure 2A); type II, defect size between one-third and two-thirds the size of the glenoid fossa (Figure 2B); and type III, defect size more than two-thirds the size of the glenoid fossa (Figure 2C).

Reconstruction protocols for skull base erosion

Our reconstruction principles for skull base erosion were as follows: for type I (the smallest) erosions, we placed a free fat graft derived from preauricular or periumbilical subcutaneous tissue to avoid intra-articular adhesion; for type II (the larger) erosions which were half the size of the glenoid fossa and associated with a risk of intracranial dislocation of the mandibular condyle, a pedicled deep temporal fascial fat flap (DTFFF) [7] was strong enough to be placed to protect brain tissue; for type III erosions which were somewhat larger than the entire glenoid fossa, bone grafts were used to support condylar compression.

Results

Patient characteristics

A total of 33 (6.4%) patients had skull base erosions exposing the dura (Table 1). The median age at the time of operation was 45 years (mean 43.4; range 13–73) years. Of all of the patients, 39.4% (n = 13) were female, and 60.6% (n =20) were male. Of all of the patients, 39.4% (n = 13) were on the right, and 60.6% (n =20) were on the left side. The histopathological tumor types included synovial chondromatosis (n=12), giant-cell tumor of the tendon sheath (n=12), giant-cell tumor of the temporal bone (n=3), synovial chondrosarcoma (n=2), chondrosarcoma (n=1), Langerhans cell histiocytosis (n=1), osteochondroma (n=1), and synovitis (n=1).

Because preoperative thin-layer CT and MRI yielded precise data, the defect sizes could be accurately measured. During the operation, the defect size was measured again, and did not significantly differ from that revealed by imaging. Thus, the operative classification was identical to the radiological classification. Five patients (15.2%) had type I erosions, 8 patients (24.2%) had type II erosions, and 20 patients (60.6%) had type III erosions.

Reconstruction of the condyle

In nine patients (27.3%), the tumors could be directly removed and the condyle was not involved; the condyles were left in place. Thirteen patients (39.4%) had tumors in the infratemporal fossa, without condylar involvement, but the tumors were too big to allow direct removal. The condylar neck was temporarily cut and the condyle was pulled aside to afford wider surgical field in terms of tumor exposure. After tumor removal, the condylar neck was reduced and fixed [8,9]. When the condyle was involved (11 patients), condylectomy was performed, accompanied by autogenous bone graft reconstruction in nine patients (27.3%) and prosthesis placement in two patients (6.1%).

Reconstruction of skull base defects

Of the five type I patients, three received free fat grafts from preauricular subcutaneous tissue (Figure 3) and the other two received DTFFFs to avoid intra-articular adhesion, because it had been necessary to resect the articular eminence. Eight type II patients received DTFFFs to separate intracranial from extracranial tissue (Figure 4). Of 20 type III patients, 17 received autogenous bone grafts including free monocortical iliac bone grafts in 13 patients (Figure 5) and free bicortical temporal bone grafts in 4 patients; the other 3 patients received prostheses including titanium mesh in 1 patient and total alloplastic joints in 2 patients, to protect brain tissue and support condylar compression. The dura was involved in two type III cases with giant-cell tumor of the tendon sheath, and was partially resected and repaired with a temporal fascia graft; the skull base reconstruction method used was the same as that used for the other cases.

Follow-up

There were no severe complications such as CSF leakage, secondary meningitis, or wound infection. Two patients with synovial chondrosarcoma and one with chondrosarcoma underwent additional radiotherapy 1 month after surgery. The mean duration of clinical follow-up was 50 months (range 3–132 months). All of the patients exhibited stable occlusions and good facial symmetry, with an average mouth-opening of 33.2 mm (range, from 22 to 40 mm). Six months after surgery, pain and discomfort had disappeared. Two patients exhibited facial nerve weakness 1 year after surgery. Postoperative CT or MRI were performed immediately after surgery, after 6 months, and annually thereafter. No recurrence was noted during follow-up. However, one patient with synovial chondrosarcoma developed pulmonary metastasis 2 years after surgery. No resorption of bone grafts or screw loosening was noted, even after radiotherapy.

Discussion

Because of the close relationship between the TMJ and the middle cranial fossa, the TMJ may be considered a part of the lateral cranial base. TMJ-SB region should be regarded as a compound system including the TMJ and the lateral cranial base. Some TMJ neoplasms exhibit subcranial extensions and destroy the base of the skull.

Surgical ablation always requires extensive resection. However, to ensure a good quality-of-life, success includes not only complete resection but also reconstruction of the TMJ function. Many methods have been used to reconstruct condylar defect such as coronoid process, posterior border of ramus, costcondral graft, sternoclavicular joint, iliac crest, vascularized metatarsophalangeal joint, fibular flap and alloplastic materials [10-13]. However, reconstruction of the skull base has received little attention. Some reports have found that the middle cranial fossa is violated after TMJ reconstruction [14-16]. For neurosurgeons and ENT surgeons, the primary goals of skull base reconstruction are to repair dura exposure and to separate intracranial and extracranial contents, preventing CSF leak and intracranial infection. A second aim is restoration of the three-dimensional appearance of bony and soft tissue [17-18]. However, in the TMJ-SB region, it is also necessary to restore the glenoid fossa and re-establish TMJ symmetry and function.

Although many skull base reconstructions have been performed, the TMJ-SB region remains poorly addressed because no universally recognized staging protocol is available. Complications that develop after TMJ-SB surgery include CSF leakage, secondary meningitis, and cerebral trauma. In addition, facial symmetry, TMJ function and occlusion are negatively affected in the absence of appropriate treatment. Apart from condylar reconstruction, such complications are associated with both the size of the skull base defect and the type of graft used for skull base reconstruction.

Here, we classified skull base erosion into three types by according to the defect size relative to the maximal cross sectional area of the mandibular condyle. Essentially, we explored whether the residual skull base could support condylar pressure. Our classification usefully guided operative treatment.

Type I defects were less than one-third the size of the glenoid fossa, which was almost fully integrated; the bony structures of the TMJ were not affected. The object of repair was not to protect brain tissue, but rather, to avoid intra-articular adhesion. Our previous experience suggested that a free fat flap from the preauricular subcutaneous tissue grafted into the TMJ cavity would survived for a long time, with a final survival rate of about 48.44% [19]. In addition, preauricular free fat flaps can be harvested from the intraoperative field, and usefully avoid the adhesion and fill the bony perforation.

Type II defects were one-third to two-thirds the size of the glenoid fossa, most of which was preserved and was sufficiently strong to support the condyle. The aim of reconstruction was to separate intracranial and extracranial contents; we used DTFFFs pedicled with the middle temporal vessels to this end. Blood supply by the vessels maintained flap softness and thickness. The flap closed erosion, protected the dura and filled the space occupied by the original tumor. Flap softness aided condylar movement, and the flap thickness increased the strength of the fossa [7].

Type III defects were more than two-thirds the size of the glenoid fossa, most of which was absent. In the literature, the reconstructive options for lateral skull base defects include primary closure, skin grafting, local rotational grafting or primary closure (i.e., using temporalis, or sternocleidomastoid flap), local rotational flaps, pedicled flaps with skin paddles, or free tissue transfer. However, when combined with condylar reconstruction, soft tissue flaps are not sufficiently strong to support the either original or reconstructed condyle. Bony reconstruction is necessary. Although, in some cases, the dura may be partially resected and repaired with autogenous or alloplastic materials, the method of skull base reconstruction does not change. Many options are available including monocortical iliac bone, monocortical or bicortical cranial bone and total alloplastic joint replacement. In this study, we used monocortical iliac bone in 13 patients, bicortical temporal bone in 4, titanium mesh in 1, and total plastic joints in 2 patients; all of them effectively prevented skull penetration by the mandibular condyle. Personalized total alloplastic joints are popular, as they are stable and associated with the need for minimal invasion. However, massive prostheses that include the skull base and the glenoid fossa are difficult to prepare. Some massive skull base defects are still reconstructed using autogenous bone grafts. Because the support and separation abilities of titanium mesh are no better than those of autogenous bone grafts and alloplastic prostheses, titanium mesh is seldom used today.

When reconstructing the condyle, we focused on functional preservation. The condyle was untouched in 9 patients (27.3%), but the condylar neck was temporarily cut in 13 patients (39.4%). When the condyle was involved (11 patients), we placed either autogenous bone grafts (nine patients) or prostheses (2 patients), which were chose depending on the patients' age, general condition and personal choice [20].

Different types of skull base defects required different treatment principles; we treated our 33 patients accordingly. All of the procedures were successful, and no recurrence occurred. The height of the ramus and the extent of occlusion were the same as those preoperatively.

Conclusions

Preoperative classification based on CT or MRI helps the surgeon choose an appropriate surgical procedure. Our classification and reconstruction principles reliably ensured successful morpho-functional reconstruction.

References

1. Al-koshab M, Nambiar P, John J. Assessment of condyle and glenoid fossa morphology using CBCT in South-East Asians. *PLoS One* 2015; 10: e0121682.
2. Shen Y, Ma C, Wang L, Li J, Wu Y, Sun J. Surgical management of giant cell tumors in temporomandibular joint region involving lateral skull base: a multidisciplinary approach. *J Oral Maxillofac Surg* 2016; 74: 2295-2311.
3. Safaee M, Oh T, Sun MZ, Parsa AT, McDermott MW, El-Sayed IH, Bloch O. Pigmented villonodular synovitis of the temporomandibular joint with intracranial extension: Acase series and systematic review. *Head Neck* 2015; 37: 1213-1224.
4. Prasad SC, Piccirillo E, Nuseir A, Sequino G, De Donato G, Paties CT, Sanna M. Giant cell tumors of the skull base: case series and current concepts. *Audiol Neurootol* 2014; 19: 12-21.
5. Dalili H and Dalili Kajan Z. Eosinophilic granuloma of the skull base: patient with unique clinical moreover, radiographic presentation. *Acta Medica Iranica* 2015; 53: 69-73.
6. Lv H, Fan Z, Han Y, Xu L, Wang H. A case of pseudogout of the temporomandibular joint with giant cellreparative granuloma of the temporal bone. *Am J Otolaryngol* 2013; 34: 762-765.
7. Jiang B, Yang C, Chen MJ, Cai XY. Synovial chondromatosis of the temporomandibular joint with articular eminence extension. *J Craniofac Surg* 2012； 23: 716-718.
8. Yang XJ Jr, Yang C, Chen MJ, Zhang XH, Qiu YT, He DM, Wang LZ. Preauricular transcondylar approach for basal cell adenoma of parotid coexist with ganglion cyst of the ipsilateral temporomandibular joint. *J Craniofac Surg* 2011; 22: e23-26.
9. Ye ZX, Yang C, Chen MJ, Abdelrehem A. A novel approach to neoplasms medial to the condyle: a condylectomy with anterior displacement of the condyle. *Int J Oral Maxillofac Surg* 2016; 45: 427-432.
10. Khadka A, Hu J. Autogenous grafts for condylar reconstruction in treatment of TMJ ankylosis: current concepts and considerations for the future. *Int J Oral*

Maxillofac Surg 2012; 41: 94–102.

11. Chen MJ, Yang C, Qiu Y, He D, Huang D, Wei W. Superior half of sternoclavicular joint pedicled with sternocleidomastoid muscle for reconstruction of the temporomandibular joint: a preliminary study with simplified technique and enlarged indications. *Int J Oral Maxillofac Surg* 2015; 44: 685-691.
12. Huang D, Lu C, Yao Z, He D, Yang C. A Comparison of the Effect Between Coronoid Process Graft and Costochondral Graft in the Reconstruction of Temporomandibular Joint. *J Craniofac Surg* 2016; 27: e197-200.
13. Qiu YT, Yang C, Chen MJ. Endoscopically assisted reconstruction of the mandibular condyle with a costochondral graft through a modified preauricular approach. *Br J Oral Maxillofac Surg* 2010; 48: 443-447.
14. Berarducci JP, Thompson DA, Scheffer RB. Perforation into the middle cranial fossa as a sequel to use of a proplast-Teflon implant for temporomandibular joint reconstruction. *J Oral Maxillofac Surg* 1990; 48: 496-498.
15. Lindqvist C, Sijderholm AL, Hallikainen D, Sjijvall L. Erosion and heterotopic bone formation after alloplastic temporomandibular joint reconstruction. *J Oral Maxillofac Surg* 1992; 50: 942-949.
16. Lypka M, Urat Ma, Hammoudeh J. Delayed middle cranial fossa perforation after autologous temporomandibular joint reconstruction. *J Oral Maxillofac Surg* 2011; 69: 1613-1616.
17. Chang DW, Langstein HN, Gupta A, De Monte F, Do KA, Wang X, Robb G. Reconstructive_management_of_cranial base_defects_aftertumor_ablation. *Plast Reconstr Surg* 2001; 107: 1346-1355.
18. Patel NS, Modest MC, Brobst TD, Carlson ML, Price DL, Moore EJ, Janus JR. Surgical_management_of_lateral_skull base_defects. *Laryngoscope* 2016; 126: 1911-1917.
19. Shen P, Qi Sun, Weifeng Xu, Jinze Zhen, Shanyong Zhang, Chi Yang. The fate of autogenous free fat grafts in the human temporomandibular joint using magnetic resonance imaging. *J Craniomaxillofacial Surg* 2015; 43: 1804-1808.
20. Chen MJ, Yang C, Qiu Y, He D, Huang D, Wei W. Superior half of

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Tables

Table 1 General information on patients with TMJ neoplasms featuring skull base erosion

	n	%
Gender		
Male	20	60.6%
Female	13	39.4%
Location		
Right	13	39.4%
Left	20	60.6%
Histopathological type		
Synovial chondromatosis	12	36.4%
Giant-cell tumor of the tendon sheath	12	36.4%
Giant-cell tumor of temporal bone	3	9.1%
Synovial chondrosarcoma	2	6.1%
Chondrosarcoma	1	3.0%
Langerhans cell histiocytosis	1	3.0%
Osteochondroma	1	3.0%
Synovitis	1	3.0%
Classification of skull base erosion		
Type I	5	15.2%
Type II	8	24.2%
Type III	20	60.6%
Reconstruction of the condyle		
Retention of the condyle	9	27.3%
Temporary condylectomy and reduction after tumor removal	13	39.4%
Autogenous bone graft	9	27.3%
Prosthesis	2	6.1%
Reconstruction of skull base erosion		
Free fat flap	3	9.1%
DTFFF	10	30.3%
Bone graft	17	51.5%
Prosthesis	3	9.1%

DTFFF: pedicled deep temporal fascial fat flap

Legends

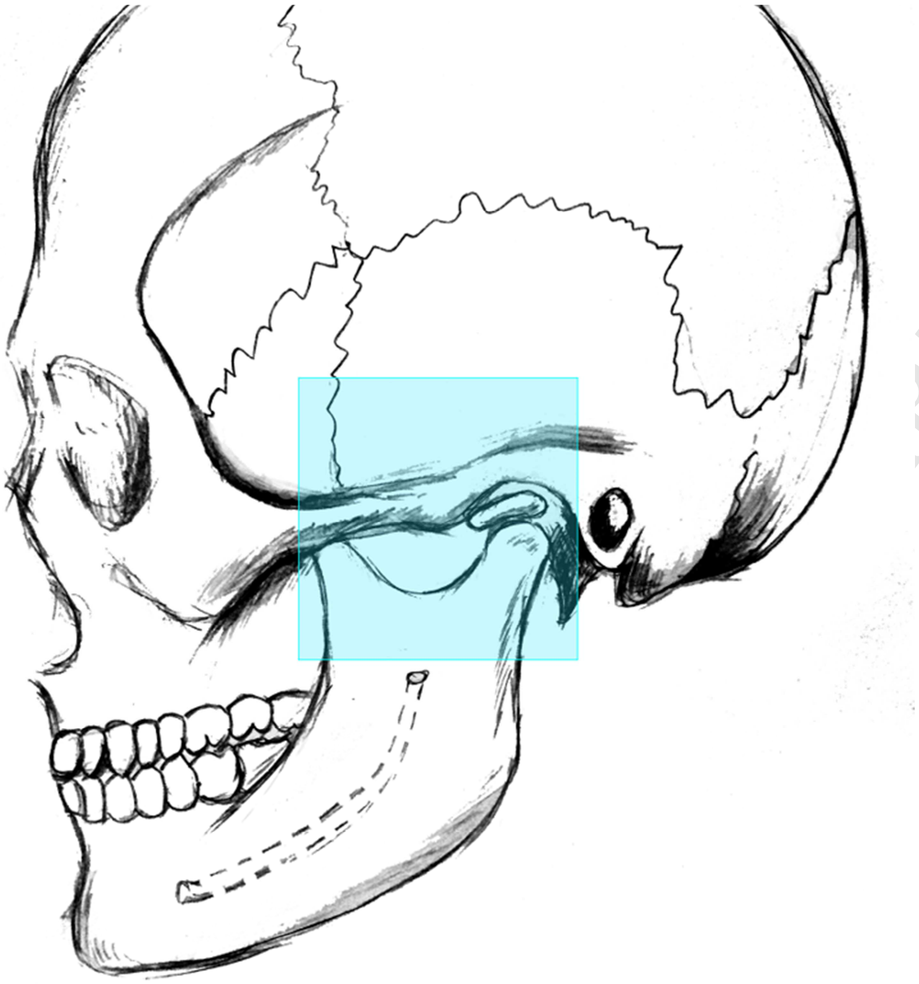
Figure 1 Sketch map of the temporomandibular joint and skull base (TMJ-SB) region. A, lateral view of the TMJ-SB with the superior border (the temporal bone), inferior border (the mandibular lingula), anterior border (the posterior wall of the maxillary sinus), and posterior border (the external auditory canal); B, superior view of the TMJ-SB with the medial border (the ovale foramen); C, anterior view of the TMJ-SB with the lateral border (the skin) and the medial border (the external lamina of the pterygoid process).

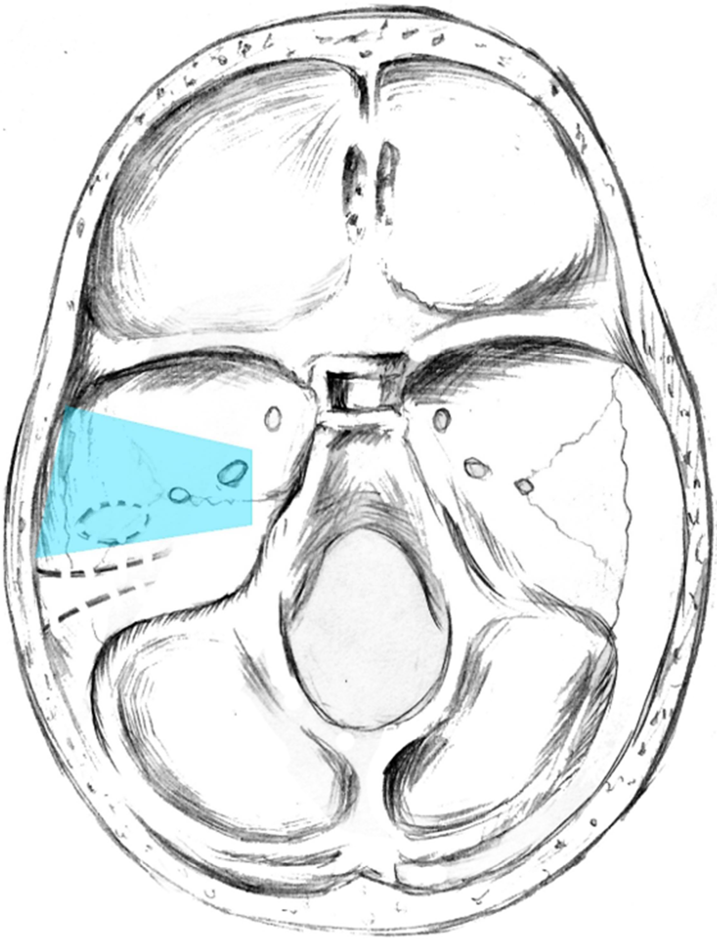
Figure 2 Sketch map of the classification of skull base erosion. A, type I, the defect was less than one-third the size of the glenoid fossa; B, type II, the defect was between one-third and two-thirds the size of the glenoid fossa; C, type III, the defect was more than two-thirds the size of the glenoid fossa.

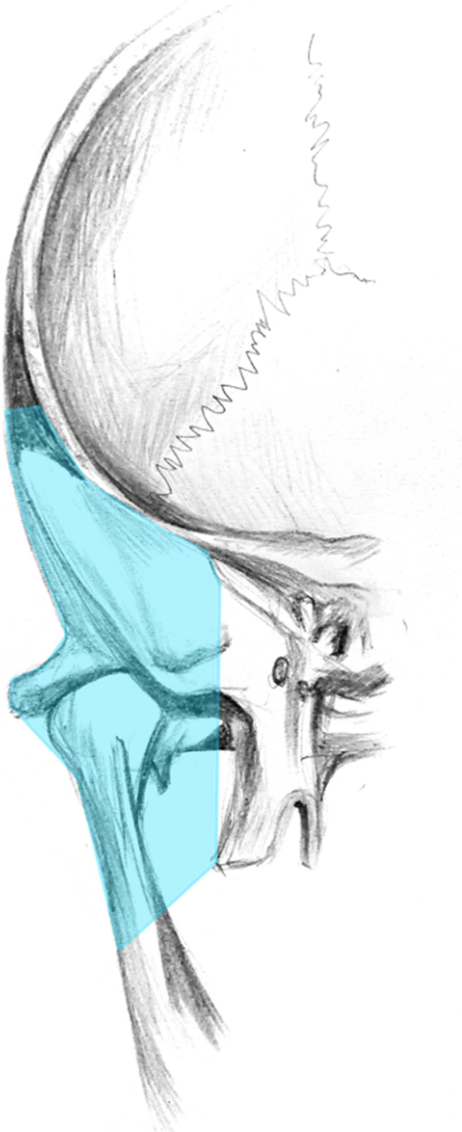
Figure 3 A case of synovial chondromatosis with Type I skull base defect. A, preoperative sagittal MRI with a small perforation of the glenoid fossa; B, the free fat graft from preauricular subcutaneous tissue; C, the upper compartment of the TMJ filled with the free fat graft to repair the perforation; D, postoperative sagittal MRI with fat tissue in the upper compartment 6 months after surgery.

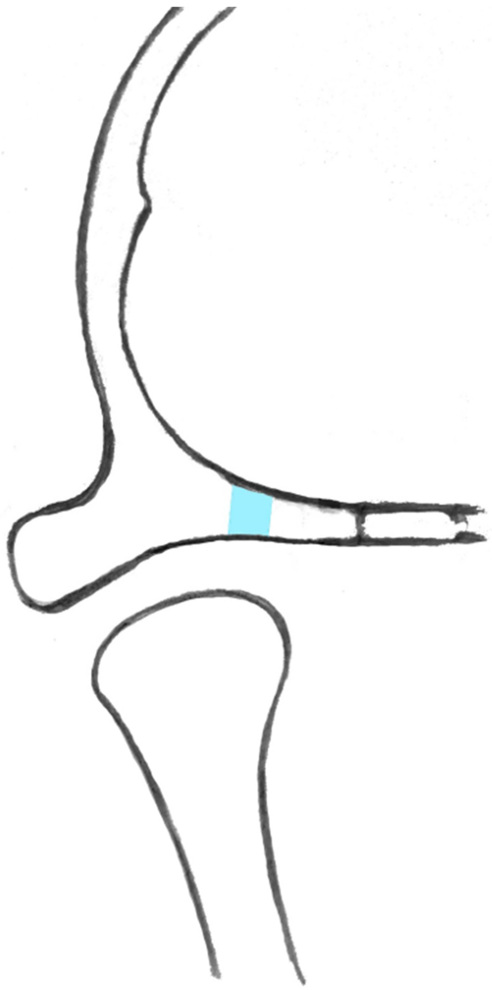
Figure 4 A case of synovial chonddromatosis with Type II skull base defect. A, preoperative coronal CT with a skull base erosion half as large as the glenoid fossa; B, the pedicled deep temporal fascial fat flap (DTFFF); C, repair of the skull base erosion with the DTFFF; D, postoperative coronal MRI with the DTFFF in the upper compartment 36 months after surgery.

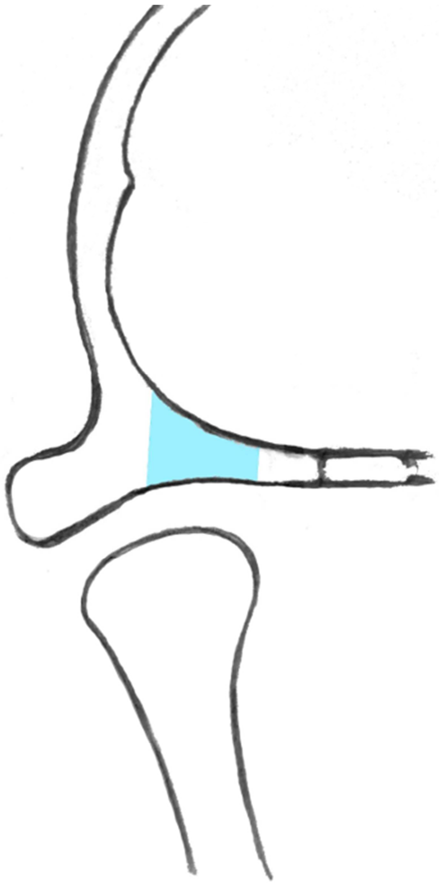
Figure 5 A case of chondrosarcoma with Type III skull base defect. A, preoperative coronal CT with a skull base erosion of a size greater than that of the glenoid fossa; B, the large skull base defect after tumor removal; C, a free monocortical iliac bone graft was harvested and shaved to fit the defect, and then fixed to the skull base with the cortical surface contacting the extracranial tissue; D, postoperative coronal CT revealing skull base reconstruction with the iliac bone graft and condylar reconstruction with the costochondral graft 96 months after surgery; E, mouth opening (30 mm); F, stable occlusion 96 months after surgery.

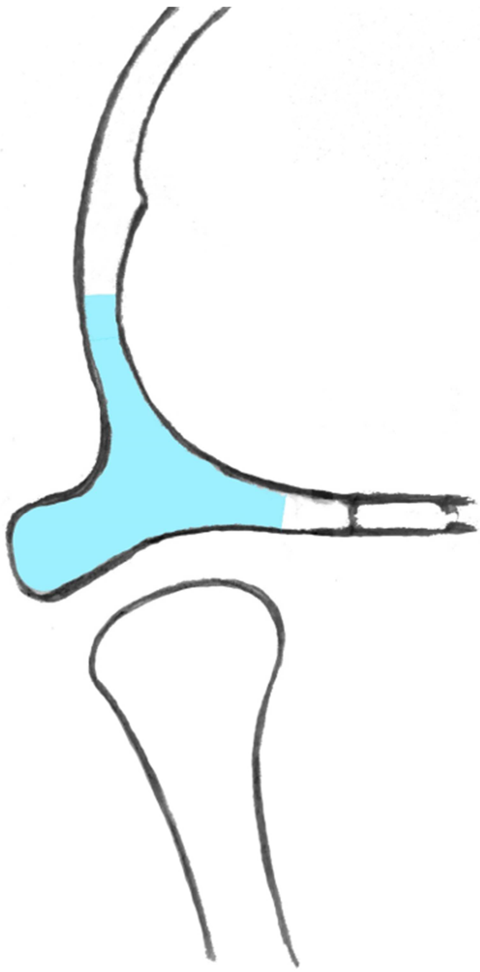


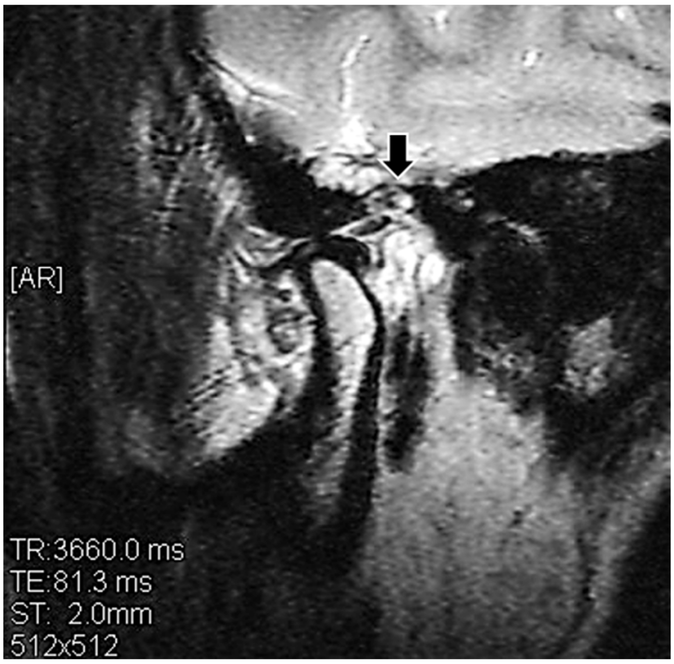








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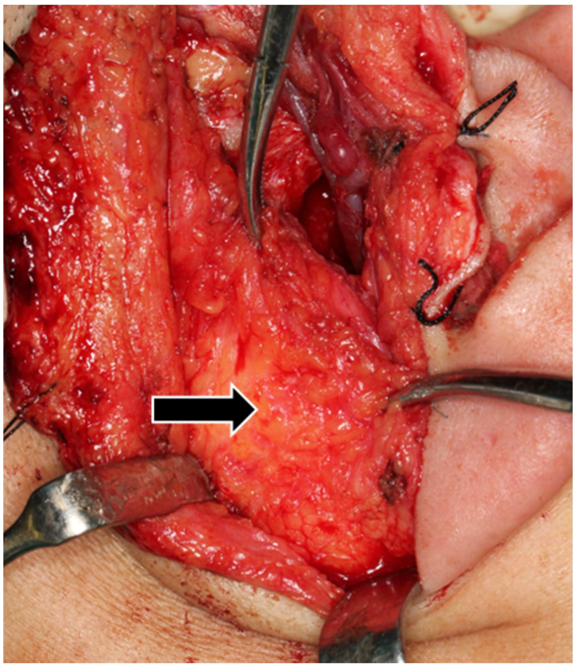

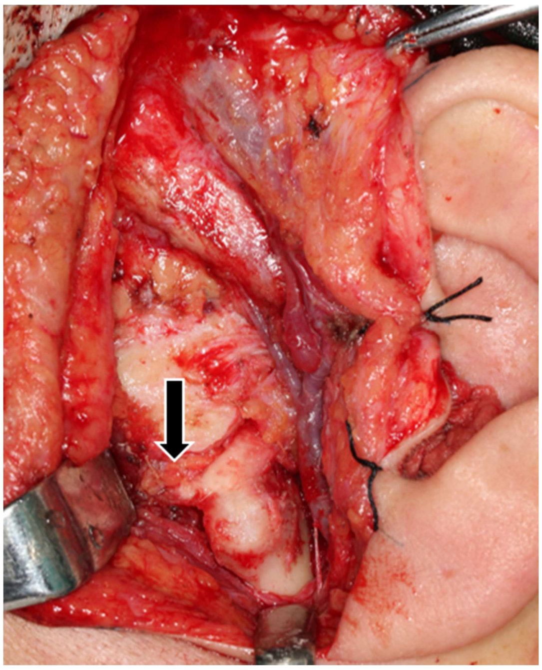

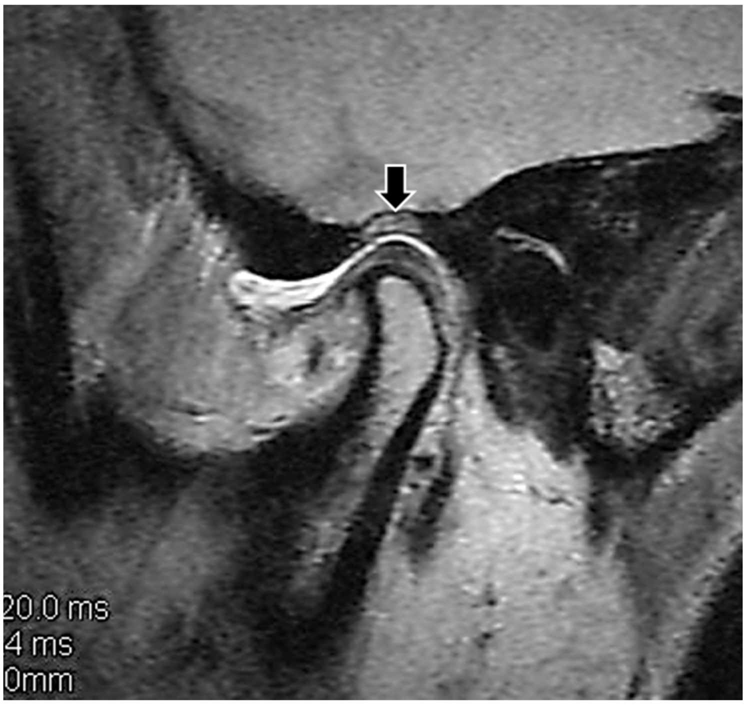
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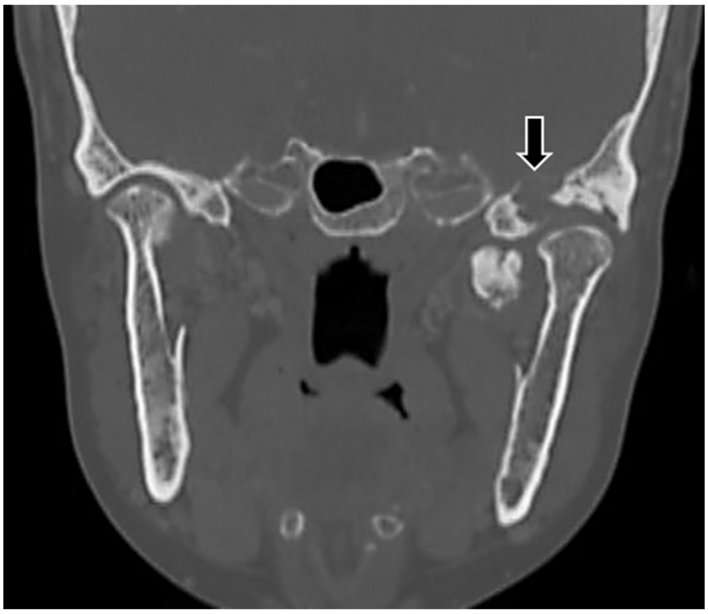

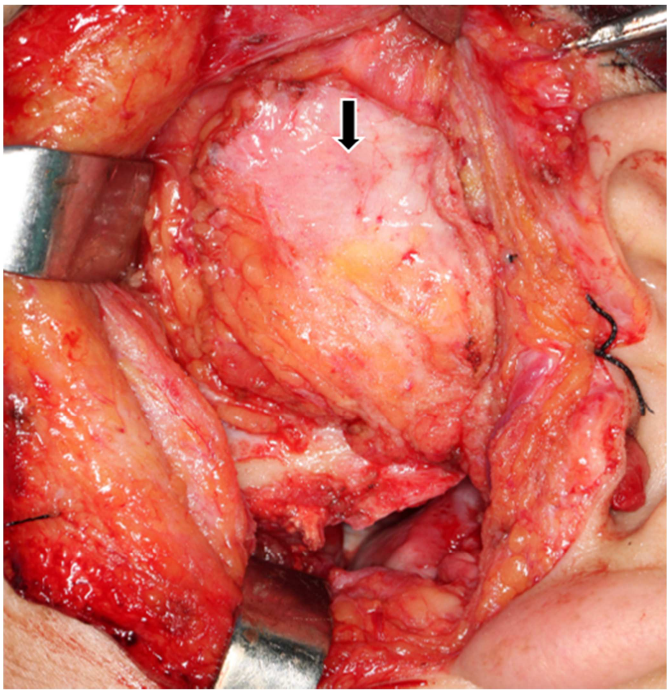

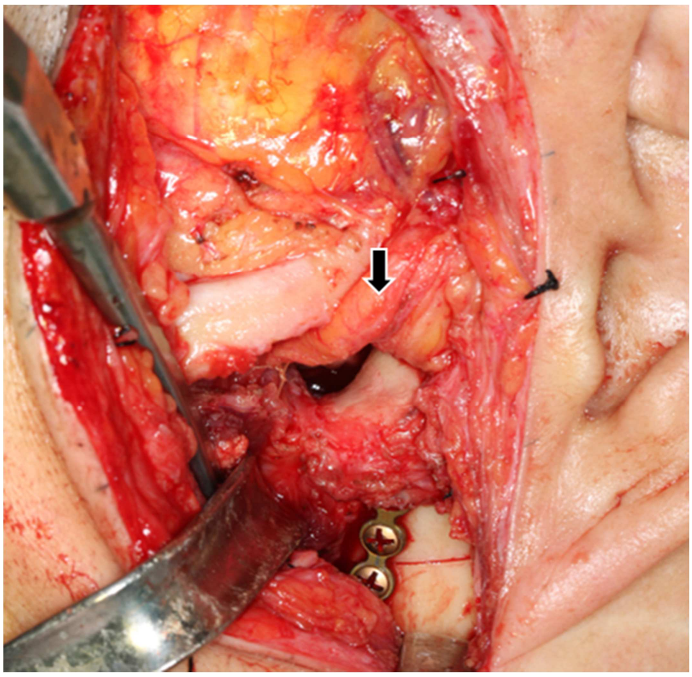

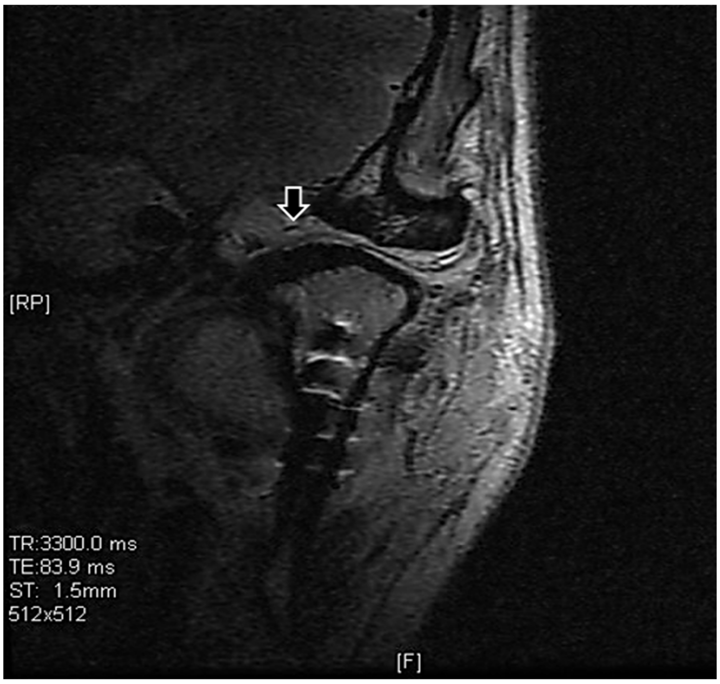
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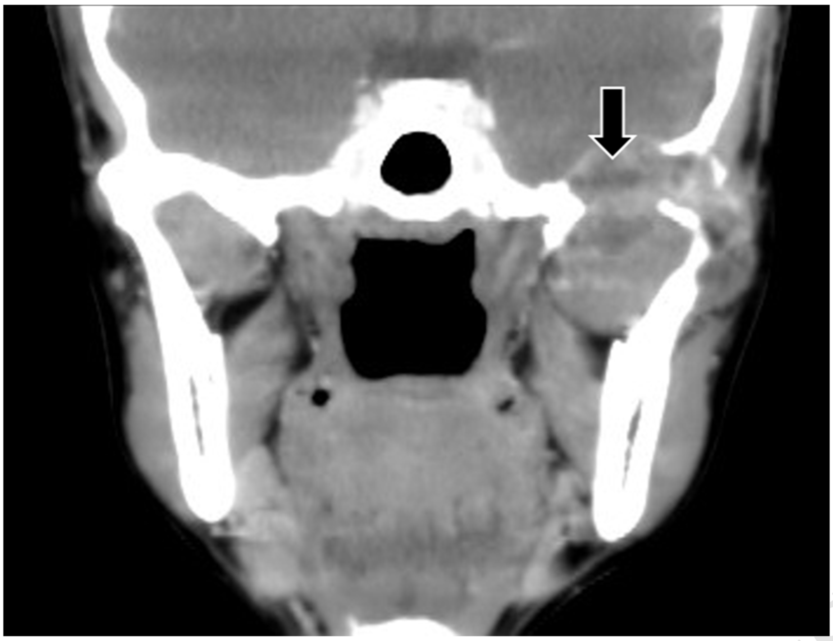

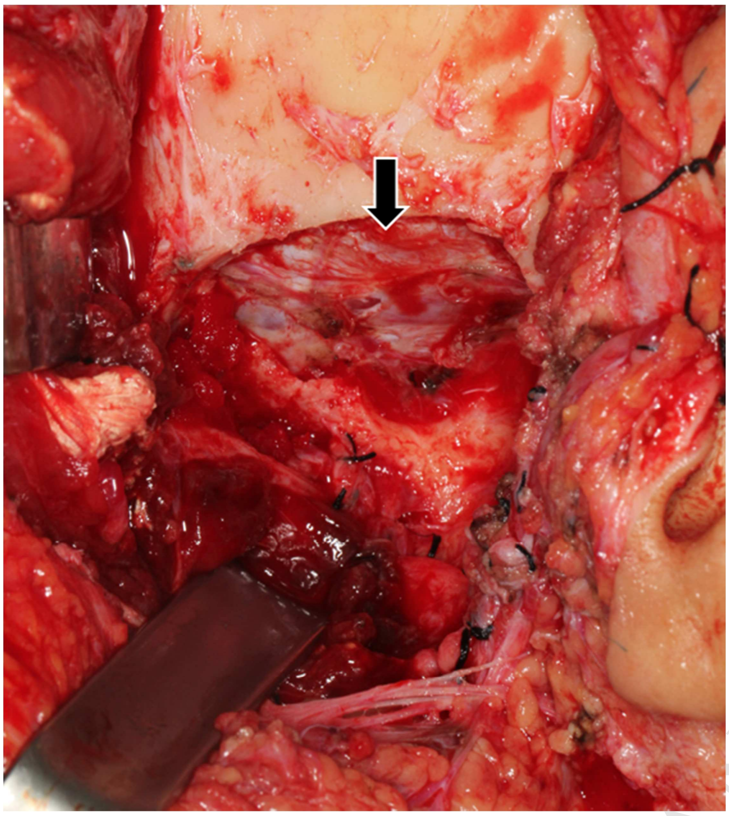

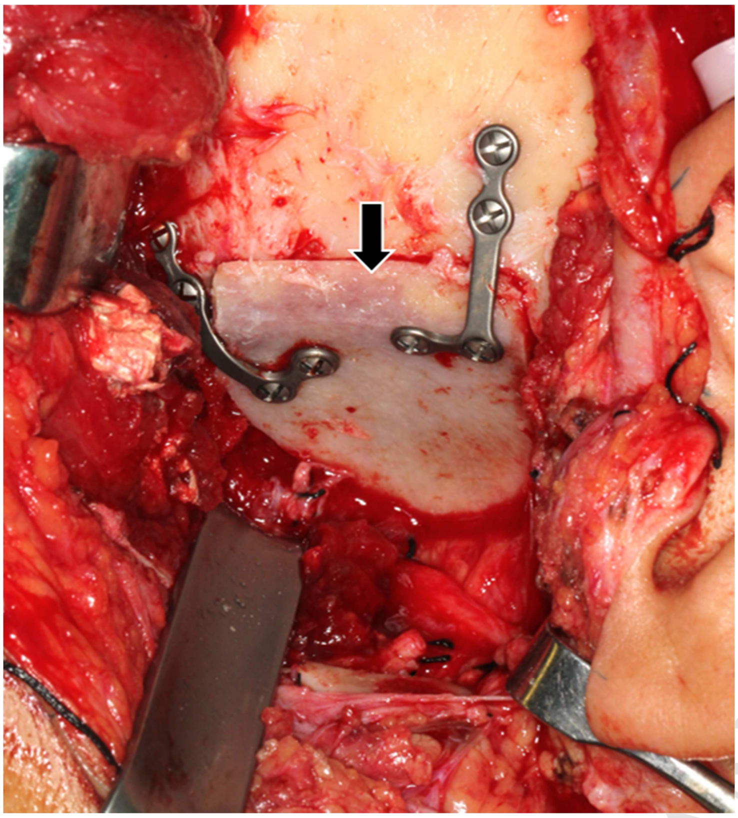


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