Clinical application of artificial bone in the maxillofacial region

Abstract Hard tissue reconstruction is very useful for bony defects of the maxillofacial region. Autogenous bone, allogeneic bone, and artificial bone have been used to reconstruct maxillofacial bone; however, the use of autogenous bone involves high surgical invasiveness because of the need to harvest the bone. The use of allogeneic bone is associated with infections, raises ethical concerns, and is not widely used in Japan. Artificial bone has several advantages, including no need for bone harvesting, excellent biocompatibility, and a relatively easy surgical procedure. Use of artificial bone avoids the much greater invasiveness of harvesting bone, and several types of artificial bone have been developed. Design requirements for artificial bone include surgical manipulability, structural compatibility with the defective area, support properties, and the ability to induce bone regeneration; however, no artificial bone meeting all these requirements has yet been developed. Artificial bone is used in many patients in our medical center, and we have been active in developing the next generation of artificial bone with better properties. In this article, we present a case history and discuss the future development of artificial bone for use in maxillofacial reconstruction.

Key words Custom-made artificial bone · Maxillofacial reconstruction · 3D model

Introduction

Autogenous bone, allogeneic bone, and artificial bone have been used to reconstruct maxillofacial bone. Use of artificial bone avoids the considerable invasiveness of harvesting bone, and several types of artificial bone have been developed. Design requirements for artificial bone include surgical manipulability, structural compatibility with the defective area, support properties, and the ability to induce bone regeneration; however, no artificial bone meeting all these requirements has yet been developed. Artificial bone is used in many patients in our medical center, and we have been active in developing the next generation of artificial bone with better properties. In this article, we present a case history and discuss the future development of artificial bone for use in maxillofacial reconstruction.

Case presentation

An 18-year-old woman was evaluated with the chief complaint of facial deformity due to progressive systemic sclerosis (PSS). She was treated and followed up by the department of dermatology at a university hospital, and the underlying PSS was stable. Her face was asymmetrical, with a depression of the middle and lower face on the right side (Fig. 1). Initially, a vascular dermal fat graft was considered, but downward displacement of the fat tissue and secondary deformity after surgery, as well as scarring at the harvest site, were of concern, especially in a young woman; therefore, hard tissue reconstruction was selected. This involved a custom-made artificial bone graft at the site of bone depression to improve the facial appearance. At the implant site, the right lower third molar was impacted and had to be extracted beforehand.
Fig. 1. Preoperative views. The patient’s face was asymmetrical, with depression of the middle and lower face on the right side.

Fig. 2. Preoperative three-dimensional (3D) computed tomography (CT) images.

Fig. 3. Three-dimensional model.
Surgery was performed under general anesthesia using an intraoral approach. An incision was made, and the periosteum was stripped from the external oblique line. The completely horizontally impacted third molar was ground and segmental extraction was performed. The periosteum was stripped at the buccal, inferior mandibular, and posterior margins. Particular care was taken at the site of muscular muscle attachment to create an implant space. A trial test with the artificial bone was performed to ensure good compatibility (Fig. 5). Holes were drilled into the mandible that corresponded to holes for wires that had been previously placed in the artificial bone. The Apaceram was
placed on the bone surface and fixated with 0.4-mm wires. The extraction cavities and surrounding bone tissue were then thoroughly dried and filled with Biopex-R (Fig. 6). Subsequent 3D CT imaging 3 months postoperatively showed no movement of the artificial bone (Fig. 7), and the patient’s facial appearance was satisfactory (Fig. 8). Currently, at 6 months postoperatively, no major complications have occurred.

Fig. 6. Insertion of artificial bone paste to the mandible

Discussion

Hard tissue reconstruction is very useful for bony defects of the maxillofacial region; however, the use of autogenous bone involves high surgical invasiveness because of the need to harvest the bone. In patients with large bony defects, a vascular pedicle flap, microvascular anastomosis, and careful design of the bone structure to fit the implant site are necessary. This requires a highly experienced surgeon.\textsuperscript{1,2} The use of allogeneic bone is associated with infections, raises ethical concerns, and is not widely used in Japan. Artificial bone has several advantages, including no need for bone harvesting, excellent biocompatibility, and a relatively easy surgical procedure. On the other hand, the risk of infection, and, depending on the material, more difficult fabrication during surgery are potential disadvantages. Table 1 lists the artificial bone materials that are currently available commercially in Japan; they are broadly divided into hydroxyapatite\textsuperscript{3} and alpha- and beta-tricalcium phosphate (\(\alpha\)-TCP and \(\beta\)-TCP).\textsuperscript{4,5} Each has specific properties that are clinically useful in treating bony defects.\textsuperscript{6,7}

In the present patient, a combination of Apaceram (hydroxyapatite) and Biopex-R (\(\alpha\)-TCP paste) was used. In Apaceram, the hydroxyapatite is sintered to form numerous continuous pores. During osteogenesis, the ingress of collagen induces bone formation within the pores.\textsuperscript{8,9} This provides good tissue affinity and direct bonding with the bone.\textsuperscript{10} In addition, compared to human bone, it is mechanically strong, but during surgery, fabrication and molding can be difficult. Therefore, the design of custom-made artificial bone is important in presurgical planning. To minimize the need for fabrication during surgery, reconstructed 3D data were used to design a model of the Apaceram bone graft prior to surgery. This bone graft model was used during surgery. In cranial bone reconstruction, digital data from 3D CT have been used to design custom-made cranial plates.\textsuperscript{11,12} But in the maxillofacial region, results based on creating mirror images of the unaffected side may be less than satisfactory. The ideal design of custom-made artificial bone permits improved soft tissue configuration over the implanted bone. The ability of the surgeon to design custom-made artificial bone, as described in this case, is clinically useful.\textsuperscript{13,14} This is highly effective during surgery and elimi-

Fig. 7. Postoperative 3D CT images
nates many of the problems that are encountered when using block bone grafts.\textsuperscript{13}

Biopex-R (\(\alpha\)-TCP) consists of a powder and a malaxation liquid, which becomes a paste upon mixing and hardens by hydration. It is a bone filler with good tissue affinity and it is an osteoconductive material. Biopex-R is gradually converted to hydroxyapatite in the body, is resorbed and replaced, and new bone is formed by osteoblasts. It has good osteoconductivity and high biocompatibility, and it is a bone substitute. The paste form makes it easy to handle and its indications as a bone filler in the maxillofacial region are increasing. However, prior contact with blood can inhibit hardening, making it difficult to retain its configuration, and the risk of infection is increased, so Biopex-R is used as an adjunct. Therefore, when using artificial bone materials with different characteristics, it is important to understand the advantages and disadvantages of each material. In the present case, Biopex-R was useful in the extraction cavities and for the binding of small spaces between the bone and the Apaceram.

The difficulty in using artificial bone for the treatment of the maxillofacial region lies in the varying sizes and configurations required for each patient.\textsuperscript{11} The ability of the surgeon to design and fabricate artificial bone for each individual patient represents a major advance in maxillofacial reconstruction.\textsuperscript{15} We are currently developing the next generation of artificial bone made from solid-type \(\alpha\)-TCP. A major characteristic of this new artificial bone is that the material is not sintered, thus facilitating resorption and replacement by bone. Since time is not required for adhesion with bone, as with current artificial bone materials, bone regeneration is more rapid. Moreover, in the development of the next generation of artificial bone, the addition of bone inducers to these materials is promising.

**Conclusion**

The combination of custom-made artificial bone and bone paste is clinically useful in maxillofacial reconstruction.

**References**