Application of allograft and absorbable screw in the reconstruction of massive bone defect following resection of giant osteochondroma: a retrospective study

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Research Article

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Abstract

Background: This study aims to introduce a reconstruction method that applicating allograft and absorbable screw to repair large bone defect caused by resection of giant osteochondroma.

Methods: A retrospective study of a series of patients who underwent the resection of giant osteochondroma reconstructed by allograft and absorbable screw was conducted from February 2020 to September 2021. Their demographic data, location site, osteotomy length and pertinent operative details were recorded. Reconstruction modality allograft were elaborated. In the follow-up, radiographic images were utilized to determine bone union, and the Musculoskeletal Tumor Society (MSTS) score was used to evaluate the postoperative limb function.

Results: A total of 7 patients were included, including 3 males and 4 females with an average age of 16.6±6.5 years. Among them, 3 cases of tumors occurred in humerus and 4 cases in femur. The average follow-up time was 11.3±3.0 months. The average area of bone graft was 25.9±8.3 cm^2. No complications such as infection, nonunion and allograft bone fracture were found during the follow-up period. At six months after operation, the average MSTS score was 26.4±1.6 with acceptable postoperative function.

Conclusions: The cooperative application of absorbable screw fixation and allograft including mixed cortical bone and cancellous bone which yielded satisfactory functional outcomes and acceptable postoperative complications, is an effective reconstruction method for massive bone defect after the resection of giant osteochondroma.

Background

Osteochondroma is the most common benign bone tumor. Most osteochondromas are asymptomatic. The main symptoms are mechanical compression, fracture, bursitis or malignant transformation of adjacent structures [1–4]. At present, the main surgical treatment of osteochondroma is tumor resection, which aims to excise the tumor beyond safe margin, maintain biomechanical supporting and achieve satisfactory postoperative functional outcomes. Complete resection of exostosis, cartilage cap and perichondrium from the base of normal bone is the recommended intervention. If the resection region of the tumor is inadequate or there remain residuals of cartilage and perichondrium, there is a high risk of recurrence [5–8].

A wide surgical margin aims to reduce the risk of tumor recurrence. However, for some large osteochondromas, complete resection of the tumor will leave a massive bone defect inevitably. This massive bone defect may lead to unsatisfactory postoperative functional outcomes. According to the previous studies on the biomechanical analysis of the defect in long bone, if the length of the defect exceeds a certain degree, it will affect the shear strength and anti-bending load of the remaining shaft after tumor resection [9, 11, 12]. Therefore, it is necessary to actively carry out reconstruction surgery following the resection of tumor in order to restore its biomechanical stability. We proposed a surgical

technique of using allograft cortical bone and cancellous bone combined with absorbable screw fixation to reconstruct the huge bone defect after osteochondroma resection. The usage of allograft can provide mechanical support for the bone defect. At the same time, cancellous bone was used to fill the gap left after the bone graft, which can increase the bone contact area between allograft and host bone. The enlarged contact surface is capable of accelerating the process of creeping substitution between allograft and host bone, and can achieve ideal osteoinductivity to shorten the time of bone graft fusion. In addition, absorbable screws were used to ensure a temporary stability because the texture of allograft is more brittle than normal bone.

The purpose of this study is to evaluate the feasibility of our reconstruction technique of bone defect.

Methods

Demographics

Based on the hospital data, we searched the medical records of all patients who underwent osteochondroma research from February 2020 to September 2021, and a total of 7 patients (3 male and 4 female patients) who received allograft were included in this study. Patients were followed for a minimum of seven months (mean, 11.3 months; range, 7–14 months). Pertinent operative details such as surgery duration, estimated blood loss and complications were also recorded (Table 1.). This retrospective study was approved by our institutional review committee. All participants agreed with the data and publication of the manuscript.

Table 1
Osteochondroma patients' demographics(n = 7)

Demographic	Value
Age(yr)	16.6 ± 6.5
Sex, male : female	3: 4
Location	3
Humerus	4
Femur	25.9 ± 8.3
The area of bone graft(cm^2)	173.6 ± 65.2
The surgery duration(min)	181.4 ± 66.4
Intraoperative blood loss(ml)	
Follow-up time(mth)	11.3 ± 3.0
MSTS score at 6 months after operation	26.4 ± 1.6
Values are presented as mean ± standard deviation or number	

Surgical technique

After the success of general anesthesia, the patients were taken supine position, and the operation area was routinely disinfected and wrapped. The incision was selected according to the location of the tumor, and the skin, subcutaneous tissue and deep fascia were cut in turn, the muscle and periosteum were stripped off, the tumor was exposed, and the tumor tissue was separated from the surrounding normal tissue. During the operation, piezosurgery was used to cut the edge of the tumor, dished to remove the tumor, and sent to routine pathological examination. After the allograft cortical bone plate and cancellous bone were properly repaired in accordance with the shape of the bone defect, the allogeneic bone plate and cancellous bone were implanted into the bone cortical defect. Then 3 absorbable screws were fixed for sake of a temporary stability. Intraoperative radiographs were reviewed to assess the effect of bone graft. Antibiotics were used once before operation (Fig. 1.).

Clinical follow-up

X-ray examination was performed every three months after operation to evaluate the implantation and fusion of allogeneic bone (Fig. 2.). The patients were assessed by Musculoskeletal Tumor Society (MSTS) score six months after the operation. In the course of follow-up, we attached great importance to the movement of limbs of patients and their postoperative rehabilitation.

Results

The mean age of the patients was 16.6 years, ranging from 13 to 31 years. In this investigation, 3 patients had tumors in the humerus and 4 in the femur. The mean area of bone graft was 25.9 ± 8.3 cm^2. The average time of surgery was 173.6 ± 65.2 minutes. The estimated intraoperative blood loss was 181.4 ± 66.4 ml. The average follow-up was 11.3 ± 3.0 months, ranging from a minimum of seven months to a maximum of fourteen months. None of patients was lost to follow-up, and none of them had complications such as infection, recurrence, allograft fracture, delayed union and nonunion for the time being. On the basis of the Musculoskeletal Tumor Society functional evaluation, the mean score at 6 months after operation was 26.4 ± 1.6. All patients had normal limb flexibility and had almost no pain at the most recent follow-up evaluation. They had basically no restriction on daily life and simple recreational activities. However, some limitations were still necessary with regard to the ability to bearing load in order to prevent fractures at the operative site.

Discussion

At present, the recommended surgical intervention for osteochondroma is the marginal resection. However, a large bone defect will be left after complete resection of the giant osteochondroma, although the definition of the size of massive bone defect has not been well determined [10]. Derek F Amanatullah et al. suggests in the biomechanical study of long bone defect that the more increase of the area of cortical defect, the less hardness of defective bone[12]. Moreover, the average torsional stiffness has a

strong linear correlation with the size of cortical defect, so the remaining bone after resection of bone defect is of great significance to its stability. These biomechanical analyses predicted a severe loss of torsional integrity when the cortical defect approaches 50% of the width of the femur. Therefore, it is necessary to actively carry out reconstruction surgery after the resection of osteochondroma in order to restore the biomechanical stability of defective bone [9, 11, 12].

In our surgical procedure, allograft was used to obtain the strength and mechanical stability of the reconstructed bone. In the process of bone union, the contact area of allograft and host bone needs enough matching and long-term absolute stability to complete the slow process of creeping substitution. Therefore, the allograft needs long-term protection to share the stress beyond its supporting capacity. At the same time, allogenic cancellous bone was applied in our investigation to fill in the medulla to preserve the bone mass after the defect as much as possible. The application of cancellous bone could fill the gap left after the bone graft, so that it can increase the bone contact area between allograft and host bone. The enlarged contact surface is capable of accelerating the process of creeping substitution between allograft and host bone, which could shorten the time of bone graft fusion. The usage of cancellous bone can also induce ideal osteoinduction and osteoconduction to achieve satisfactory bone union.

In our study, 3 patients had tumors in the humerus and 4 in the femur. Due to the femur and tibia are the main weight-bearing bones of the human body, the stress load after reconstruction is greater. Thus, for some patients with larger femoral defects, the allograft is fixed with steel plates and screws to strengthen the mechanical stability of the affected limb. Regarding the enhancement of the stability of allograft and reduction of the risk of fracture, Gupta S et al. reported that allograft augmented with intramedullary cement and plate fixation is a reliable solution [13, 14]. Being the non-weight-bearing bone, the humerus has a lower bearing requirement compared with femur or tibia. Therefore, we added absorbable screws for fixation instead of traditional metallic screws, and the implantation of steel plates were not necessary. Compared with the traditional plate and metallic screw fixation, this technique can reduce the use of metal materials, which can save the patients from the pain of removing the internal fixation again in the future. Besides, it has the advantages of reducing the opacity effect of metals in X-ray films and metal artifacts in CT and MRI, so we are able to make an early assessment of fusion process of cortical cancellous bone and local recurrence [15, 16]. Another benefit is that postoperative pain associated with elastic modulus mismatch may be reduced. Compared with metal plates and screws, cortical allogeneic bone scaffolds can better reconstruct the biomechanical elastic modulus of bone. In some published literature, this mismatch is considered to be one of the considerable causes of postoperative pain and eventual implant failure [17–19].

Because the texture of allograft is more brittle than that of normal bone, it is difficult for other tools to grind it into a suitable shape. As a consequence, piezosurgery was used in the process of operation to cut the interface between host bone and allograft directly into bevel in order to increase the contact area of biological bone graft and make it more matching, which could shorten the healing time and enable patients to recover and exercise early. At the same time, we ground the growth axis of the bone defect into

an oval in the same direction as the length and diameter of the bone according to precise match orientation, so as to better adapt to the biomechanics of the reconstructed bone.

In spite of allograft has been used as a biological bone preservation technique, there still remains several potential problems such as allograft fracture [20, 21, 24], infection [20–23, 25], delayed union and nonunion [5, 25–27]. In our case, none of the patients had these complications above for the time being. Although it is generally believed that the incidence of allograft is high, we found that the incidence of postoperative infection, fracture and delayed bone union is low in our study. One possible reason is that our technique can shorten the operation time, reduce intraoperative bleeding, reduce the incidence of short-term and long-term postoperative complications. As a result, patients were able to carry out simple rehabilitation training early. Passive functional exercise was necessary and could be carried out as soon as possible after operation, which can prevent muscle atrophy and anchylosis. However, the active movement of the affected limb should be restricted in the short term to avoid fractures caused by excessive load or rotational violence.

There are several limitations although our method of operation was very effective. First of all, our study was a retrospective study, which lacked a direct comparison with other treatment techniques, especially plate and screw fixation. At the same time, we currently had an average follow-up period of 11.3 ± 3.0 months, which was still shorter than that reported in relevant studies. And the population was relatively small as a result of the rarity of the procedure, so late follow-up is needed to evaluate whether there would be new long-term complications. In addition, our research can be combined with the prevalent 3D printing technology, so that we could better plan the bone defect and its reconstruction, including the development of personalized guide plate and vascularized stent [28–30]. But it also exists some shortcomings, such as high cost, long learning cycle. And the long-term outcomes and the remedy after failure of 3D printing technology have not been certified clearly [31].

Conclusions

In the reconstruction of massive bone defect after operation of osteochondroma of long bone, the use of allograft combined with absorbable screw fixation can shorten the time of bone union, so that the patients can recover early after operation. At the same time, it is also safe in terms of the risk of infection and allograft fracture. Considering that it can reduce the use of metal plate and screws, it also has some advantages in reducing the metal artifacts of CT or MRI. In addition, on account of the stiffness of the allograft is closer to the bone than metal, the limb pain associated with the difference in elastic modulus mismatch can be reduced in the meantime. Therefore, allograft combined with absorbable screw fixation is an effective method of reconstruction with satisfied functional effect and low incidence of complications.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

All presentations of case reports have consent for publication.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Zhihao Ma and Qiang Yang contributed equally to the main manuscript text and prepared figures. All authors reviewed the manuscript.

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Figures

Figure 1

(A)The preoperative X-ray of the patient showed a huge osteochondroma at the proximal end of the right humerus, with a size of 12cm*5cm*5cm. B Osteotomy was performed from the base of the tumor, and the allograft bone plate was repaired according to the condition of bone cortical defect. (C)The allograft was implanted in the bone cortical defect and fixed with 3 absorbable screws. (D)Three months after operation, X-ray showed that the bone graft was satisfactory.

Figure 2

Six months after operation, the X-ray of right humerus AP&LAT showed that the effect of bone graft fusion was desirable. However, due to only absorbable screws were used for a short-term fixation rather than plate fixation, the patient still needs to limit the heavy load and avoid rotational violence of the affected limb.