Cylindrical Costal Osteochondral Autograft for Reconstruction of Large Defects of the Capitellum Due to Osteochondritis Dissecans

Surgical Technique

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Introduction

We describe our technique of cylindrical costal osteochondral autograft for elbows with advanced osteochondritis dissecans.

Osteochondritis dissecans of the humeral capitellum is a common sports-related disorder in young athletes, especially baseball players and gymnasts. With advanced osteochondritis dissecans of the capitellum, radiocapitellar incongruity develops and treatment remains challenging, particularly with a large, full-thickness articular cartilage defect. Studies have shown that a large articular defect reaching to the lateral cortex is a risk factor for subsequent degenerative changes and should be treated with repair or reconstruction¹⁻⁴.

The ribs are a potential donor site for osteochondral grafts comprising combined hyaline cartilage and structural bone. Several authors have described costal osteochondral autograft transplantation for upper limb arthroplasty, reporting favorable clinical results with minimum donor-site morbidity⁵⁻⁷. With regard to the elbow, Oka and Ikeda reported a case of a large osteochondritis dissecans lesion reconstructed with osteochondral autograft using costal tissue, Sato et al. described several cases treated in the same manner, and Mihara et al. reported good results following this procedure, although it is technically difficult⁸⁻¹¹. To standardize the procedure for costal osteochondral autograft, we modified it to use a cylindrical graft on the basis of our experiences with multiple osteochondral plug grafts or "mosaicplasty"^{3,12}. The goal is to obtain a stable and congruent articulation, even in athletes with a large lesion, allowing restoration of a painless elbow with good function.

The procedure consists of six steps (Fig. 1):

- Step 1: Prepare and position the patient
- Step 2: Excise/debride the lesion and create a cylindrical hole
- Step 3: Elevate the costal osteochondral junction
- Step 4: Prepare the osteochondral autograft
- Step 5: Place the graft into the defect and close
- Step 6: Postoperative treatment

Step 1: Prepare and Position the Patient

Mark the ipsilateral (fifth or sixth) rib.

- Perform the operation with the patient under general anesthesia and in a supine position.
- Preoperatively, palpate and mark the ipsilateral (fifth or sixth) rib and sterilely prepare and drape the rib area (Fig. 2). Use finger suspension to apply traction to the involved upper extremity and inflate the tourniquet to 250 mm Hg.
- If loose bodies are identified, particularly on the anterior aspect of the elbow, remove them arthroscopically. When a nondisplaced large and progressed lesion is confirmed preoperatively, begin the arthrotomy without arthroscopy.
- After the suspension is released, hyperflex the elbow maximally and use a posterolateral surgical approach (in an intermuscular and internervous plane between the anconeus [radial nerve] and extensor carpi ulnaris [pos-

terior interosseous nerve], or anconeus muscle-splitting) (Fig. 3).

Step 2: Excise/Debride the Lesion and Create a Cylindrical Hole

Debride necrotic fibrous tissue completely.

- Resect detached (in osteochondritis dissecans IV, as classified with the system of the International Cartilage Repair Society [ICRS]) or unstable (in osteochondritis dissecans III) articular lesions and debride necrotic fibrous tissue completely.
- Measure the lesion diameter. The procedure being described is indicated for a lesion with a diameter of ≥ 15 mm. If the lesion diameter is < 15 mm, the procedure is possible after enlargement of the defect, although such a lesion can be generally treated with a less invasive procedure.
- Perforate the sclerotic subchondral bone, and deepen the area of the cartilage defect cylindrically to a depth of about 15 mm using a high-speed surgical burr as perpendicular as possible to the articular surface.

Step 3: Elevate the Costal Osteochondral Junction

Elevate the graft carefully from the periosteum and perichondrium to avoid damage to the pleura.

- Harvest the ipsilateral (fifth or sixth) rib at the osteochondral junction (Fig. 4 and Video 1). We prefer to use the sixth rib because it is more round and fits more easily into the osteochondritis dissecans lesion. Use a transverse incision on the sixth rib. Incise the pectoral muscle and retract bluntly to explore the rib surface.
- After making an H-shaped incision on the rib at the osteochondral junction, harvest the osteochondral graft. It is essential to elevate the graft carefully from the periosteum and perichondrium in this procedure to avoid damage to the pleura.
- After harvest of the graft, suture the split periosteum to allow formation of new bone at the donor site. Careless management of the costal bone may also result in breakage at the osteochondral junction of the graft. In case of breakage of the graft at the osteochondral junction, replace the graft to the original posi-

tion, repair the periosteum, and harvest the neighbor rib osteochondral junction.

Step 4: Prepare the Osteochondral Autograft

Shape the harvested osteochondral junction like a cone about 18 mm in height, including a 5-mm-high cartilage cap. The longer diameter of the cartilage is usually about 15 mm and the shorter diameter is about 10 to 12 mm. Residual rib is cut about 10 mm long and sliced into two corticocancellous bone wedges (Fig. 5 and Video 2).

Step 5: Place the Graft into the Defect and Close

After packing the grafts, shape and contour the cartilage surface to fit the radial head using a scalpel.

- Push and pack the graft into the prepared hole in the recipient site like a cork for a wine bottle. Never use a screwing motion; instead utilize gentle packing with a plastic rod and a hammer to avoid breakage of the osteochondral junction.
- The articular defect of the elbow is usually oval-shaped, and one osteochondral rib provided suitable fit for the defect in many of the cases in our study¹² (eleven of twenty-six cases [mean recipient site cross section, 13.9×15.8 mm]). The packed graft is so stable in a press-fit fashion that no additional internal fixation is necessary during elbow motion in these cases (Fig. 6).
- In cases with larger or round lesions (fifteen of twenty-six cases in our study¹² [mean recipient site cross section, 16.7×16.3 mm]), the piece of costal osteochondral graft is insufficient to fit the defect. In these cases, insert the sliced corticocancellous rib as a wedge into the space between the osteochondral graft and the posterolateral cortex of the recipient humerus (Fig. 7). Cancellous bone of the wedge fits stably between the graft and the recipient bone, so no internal fixation is necessary.
- Multiple ribs can be used as grafts; however, most cases can be treated with one rib graft consisting of one osteochondral graft and one or two bone wedge grafts. One of the forty-three cases that we performed since 2006 required one and a half rib grafts because the defect was too large for a single graft.

- After packing the grafts, shape and contour the cartilage surface to fit the radial head using a scalpel. This is an essential step, but it is not difficult because the costal cartilage in young patients is hyaline and shaving with a scalpel is easy (Video 3).
- After irrigation of the wounds, tightly suture the incised elbow capsule and close the subcutaneous tissues and skin in layers. For the donor costal area, have the anesthetist apply positive pressure to the lungs through the endotracheal tube after filling the wound with sterile fluid to identify possible pleural leaks and pneumothorax. Also, close stripped periosteum and perichondrium, incised membrane of the pectoral muscles, and skin in layers at this site.

Step 6: Postoperative Treatment

Most patients are able to perform normal daily activities in a few days or a week, but they are not allowed to play sports for three months.

- Immobilize the elbow with a splint in 90° of elbow flexion with the forearm in neutral rotation. Cover the costal wound with an adhesive dressing. Obtain postoperative anteroposterior and lateral elbow radiographs to identify the proper placement of the graft and an anteroposterior radiograph to rule out pneumothorax.
- Two weeks postoperatively, the splint and sutures are removed and the patient starts active motion exercises. Most patients are able to perform normal daily activities in a few days or a week, but they are not allowed to play sports for three months.
- Patients should make a step-by-step return to sports activities with some limitations once complete graft union (trabecular continuity) is seen on imaging studies. We advise patients to return to usual activities without limitation at six months postoperatively and allow baseball pitchers to start pitching while limiting the number of pitches per day and per week until twelve months postoperatively. Patients are subsequently followed every three or six months in the outpatient clinic.

Results

Between 2006 and 2010, we performed this operation in forty-three patients with severe osteochondritis dissecans of the humeral capitellum, and twenty-six cases were followed for more than twenty-four months¹². Clinical, radiographic, and magnetic resonance imag-

ing (MRI) outcomes were evaluated at a mean of thirty-six months (range, twenty-four to fifty-one months). All patients showed rapid functional improvement and returned to former activities, including sports. Five minor surgical procedures were needed, including screw removal, loose body removal, and shaving of protruded cartilage. Mean elbow function as assessed with the clinical rating system of Timmerman and Andrews¹³ was 111 points preoperatively, improving to 180 points at the time of follow-up and to 190 points at the time of final follow-up (after the additional operations). Mean elbow motion was 126° of flexion with 16° of extension loss preoperatively, improving to 133° of flexion with 3° of extension loss at the time of follow-up, and to 134° of flexion with 1° of extension loss after the additional operations. Osseous union of the graft was seen on radiographs within three months in all cases. Revascularization of the graft depicted on T1-weighted MRI and congruity of the reconstructed articular surface depicted on T2-weighted or short tau inversion recovery MRI were assessed at twelve and twenty-four months postoperatively (Fig. 8). Functional recovery was good, and all patients were satisfied with the final outcome.

What to Watch For

Indications (Fig. 9)

- Failure of more than six months of nonoperative treatment.
- A large and advanced stage of osteochondritis dissecans of the humeral capitellum. An ICRS osteochondritis dissecans III or IV lesion with a diameter exceeding 15 mm is good indication for this procedure.

Contraindications

- A patient with an open distal humeral physis at the capitellum.
- Non-advanced or smaller lesions that can be treated with other, less invasive techniques. Non-advanced lesions should be treated by fixation of the lesion (e.g., bone peg grafting), and smaller lesions should be treated with a less invasive procedure (e.g., arthroscopic debridement).
- Patients who ever experienced severe chest injury involving the costal area.

Pitfalls & Challenges

- Complete debridement of the degenerated tissues is important to avoid recurrence of free bodies.

- Too-thick donor cartilage may become necrotic and degenerated. After shaving of the surface, 1 to 4-mm-thick costal cartilage is suitable. For that purpose, precise preparation of the costal graft and the recipient hole is important.
- Breakage of the osteochondral junction may occur while a graft is being harvested. Gentle stripping of the periosteum and the perichondrium is important to avoid not only pneumothorax but also breakage of the graft.

Clinical Comments

- The overall results of cylindrical costal osteochondral autograft were generally good considering the severity of the lesions encountered, but long-term follow-up is clearly necessary.
- Long-term donor-site morbidity also must be considered, especially for young athletes.
- We used the fifth or sixth rib as a donor in this study; however, we do not know which rib is the best for the donor.

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Figures

Fig. 1

Schematic diagram of the procedure.

Fig. 2

Operation setting and arthroscopy preceding the osteochondral autograft procedure. **Top:** Marking on the ipsilateral sixth rib. **Bottom left:** Draping of the donor site and sterile preparation of the affected limb. **Bottom right:** Arthroscopic removal of loose bodies.

Fig. 3

Posterolateral surgical approach with the elbow fully flexed. **Left:** The elbow is approached posterolaterally. **Middle:** A large loose body (arrows) is excised through this approach, between the anconeus and the extensor carpi ulnaris muscle. **Right:** The lesion was deepened in a cylindrical shape to a depth of 15 mm with use of a high-speed surgical burr.

Fig. 4

Harvest of costal osteochondral graft. **Top:** H-shaped incision on the rib. Strip the periosteum and perichondrium at the osteochondral junction. **Middle:** Cut the rib with a bone saw, taking care not to damage the pleura. **Bottom:** Cut the rib cartilage with a scalpel.

Fig. 5

The costal tissue is shaped into an osteochondral graft and osseous wedges. **Left:** Costal osteochondral graft from the sixth rib. **Middle:** The graft is divided into an osteochondral graft of 18 mm in height including a 5 mm-high cartilage cap and two cortico-cancellous osseous wedges of 10 mm in height. **Right:** The usual cartilage cross section of the oval costal graft is 15 to 16 mm × 10 to 12 mm.

Fig. 6

After placement of the costal osteochondral autograft. In this case, the defect is oval-shaped and one osteochondral graft (arrows) fits the hole tightly.

Fig. 7

An operative option is to use a wedge bone graft. In this case, the defect is so large that an osseous wedge (white arrows) is inserted into the cleft between the graft (black arrows) and the lateral humeral cortex of the recipient.

Fig. 8

MRIs obtained twelve months postoperatively. **Left:** T1-weighted sagittal image showing well-revascularized subchondral bone in the graft area. **Right:** Congruent articular contours are apparent on a T2-weighted sagittal image. The patient returned to sports activity (judo) within one year.

Fig. 9

Our strategy for treatment of osteochondritis dissecans (OCD) of the elbow and the surgical indication for use of costal osteochondral autograft. Xp = radiograph.

Step#1-#2: Creation of the recipient hole

Step#3-#4: Preparation of an osteochondral graft and a bony wedge

Step#5: Completion of the procedure

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Our treatment chart for OCD of the humeral capitellum

Fig. 9