SUBSPECIALTY PROCEDURES

BONE PEG GRAFTING FOR CAPITELLAR OSTEOCHONDritis DISSECANS IN ADOLESCENT BASEBALL PLAYERS

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Abstract

Background: Capitellar osteochondritis dissecans (OCD) is a focal injury of the articular cartilage involving separation of a segment of cartilage from the subchondral bone that is infrequently encountered in the dominant-side elbow of adolescent throwing athletes^{1,2}. The literature suggests that patients may achieve better short and mid-term results when treated with certain types of surgical procedures^{3,4}. Selection of the appropriate surgical method should be based on the International Cartilage Repair Society (ICRS) OCD classification system⁵. For lesions involving $\leq 50\%$ of the surface area of the capitellum, debridement with microfracture and/or loose body removal have shown excellent results. For lesions involving $> 50\%$ of the surface area of the capitellum and classified as ICRS OCD III or IV, autologous osteochondral grafting may be the most suitable treatment⁶⁻⁸. Bone peg grafting (BPG) has been shown to be an effective treatment option for early-stage capitellar OCD that can preserve the local hyaline cartilage^{9,10}.

Description: Using direct vision and with arthroscopy, the continuity of the capitellar surface and the stability of the capitellar lesion were evaluated according to the ICRS OCD classification⁵. BPG was indicated for adolescents with ICRS OCD I or II. The elbow was opened between the extensor carpi ulnaris and the anconeus muscle (Kocher interval). Another skin incision of 3 cm in length was made at the posterior aspect of the metaphysis of the ipsilateral olecranon. Three, 4, or 5 bone pegs of approximately 20 mm in length were harvested from the posterior ulnar cortex. A Kirschner wire of 3 mm in diameter was used for drilling holes in the lesion, and then the bone pegs were inserted with tweezers to a depth of 10 mm. Next, a flat-surfaced rod was placed on the head of each bone peg to press it to a depth slightly lower than the articular cartilage surface. Postoperatively, the elbow was immobilized for 3 weeks. Throwing was allowed at 6 months, and a return to competitive baseball at preinjury levels was permitted at 8 months after BPG.

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Alternatives:

- Arthroscopic debridement of the lesion.
- Arthroscopic bone marrow stimulation or microfracture.
- Fragment fixation using metal implants or biodegradable materials.
- Use of autologous osteochondral graft from the distal aspect of the femur or from a rib.

Rationale: Our follow-up study after BPG revealed that 10 of 11 patients with ICRS OCD I or II capitellar OCD could return to their preinjury baseball ability and that 8 of the 11 lesions completely healed as seen radiographically¹¹. Radiographic and magnetic resonance imaging (MRI) findings showed that BPG could secure the lesion to the osseous floor as a physiological scaffold. Fragment fixation with metal implants or biodegradable materials carries a risk of damaging cartilage surfaces, and autologous osteochondral grafting is too invasive for this early-stage lesion. BPG is indicated for ICRS OCD I or II lesions, especially with central positioning and/or occupying <75% of the size of the capitellum in the coronal plane¹¹.

Introductory Statement

Bone peg grafting (BPG) enables adolescent baseball players with capitellar osteochondritis dissecans (OCD) classified as International Cartilage Repair Society (ICRS) stage I or II to return to preinjury levels of sports participation with a high rate of healing of the lesion.

Indications & Contraindications

Indications

- Adolescent baseball players with unhealed capitellar OCD after abstaining from throwing for ≥ 6 months.
- Capitellar OCD exhibiting a translucent cystic shadow, split line, or clear zone on tangential anteroposterior radiographs of the forearm with the elbow in 45° of flexion.
- Capitellar OCD with no high-signal interface, compared with that of cartilage, between the lesion and the osseous floor on T2-weighted magnetic resonance imaging (MRI).
- Capitellar OCD manifesting as ICRS OCD I with hyaline cartilage showing softening alone seen under direct vision or with arthroscopy.
- Capitellar OCD manifesting as ICRS OCD II with a fissure in the hyaline cartilage seen under direct vision or with arthroscopy.

Contraindications

- An age of <10 years because BPG may penetrate the open epiphyseal growth plate at the distal part of the humerus and risk growth disturbance after surgery.
- Capitellar OCD showing detached free-body formation on tangential anteroposterior radiographs of the forearm with the elbow in 45° of flexion.
- Capitellar OCD showing separation by a high-intensity line, compared with cartilage, on T2-weighted MRI¹².
- Capitellar OCD manifesting as ICRS OCD III with a dead in situ lesion seen under direct vision or with arthroscopy.
- Capitellar OCD manifesting as ICRS OCD IV with free-body formation seen under direct vision or with arthroscopy.

Step-by-Step Description of Procedure

Step 1: Select Patients on the Basis of Radiographs and MRI

The key to successful BPG is proper selection of patients based on serial preoperative radiographs and MRI (Fig. 1).

- Confirm that there is tenderness over the anterior aspect of the capitellum with the elbow in a flexed position and obtain tangential anteroposterior radiographs of the forearm with the elbow at 45°. Repeat this radiograph after 3 and 6 months of the patient abstaining from throwing to evaluate for lesion healing.
- If the radiograph does not show healing, confirm that the capitellar OCD lesion is a translucent cystic shadow in the lateral or middle part of the capitellum without a split sclerotic line between the lesion and the subchondral bone.
- Measure the lesion size in the coronal plane of a tangential anteroposterior radiograph and ascertain that it is larger than half of the capitellum.
- Use T2-weighted MRI to confirm the absence of a high-signal interface line between the capitellar lesion and subchondral bone—i.e., that it is stage 1, 2, or 3 according to the MRI classification system of Itsubo et al.¹².
- Estimate the size and occupying area of the lesion with MRI. Plan the sites, direction, and length of the bone pegs prior to surgery.

Fig. 1

Fig. 1 Treatment strategy for capitellar OCD (COCD) in adolescent baseball players. a = preoperative radiographic grading system described by Minami et al.¹⁵, and b = preoperative MRI classification system described by Itsubo et al.¹². *Itsubo stage 1 indicates spotted areas with high signal intensity that is lower than that of the cartilage, and stage 2 indicates spotted areas with high signal intensity that is higher than that of the cartilage.

Step 2: Position the Patient and Survey the Elbow Arthroscopically

Place the patient in a supine position for arthroscopic examination and treatment of the lesion.

- After induction of general anesthesia, place the patient in a supine position to make it easier to perform the operation, although evaluation of the lesion can also be performed with the patient in a lateral decubitus position. Place the affected arm on the operating room table with the shoulder in 90° of abduction and 0° of flexion and the elbow flexed 90° for arthroscopy and subsequent treatment of the capitellar lesion, including bone peg harvesting and grafting (Fig. 2).
- Inject 20 mL of saline solution into the elbow joint through a soft spot. Place a sterilized pneumatic tourniquet on the proximal part of the upper arm. Do not use it during arthroscopy.
- Hold the elbow at 90° of flexion. First, create an anteromedial portal using a 30° oblique arthroscope. Survey for the existence of free bodies and evaluate the chondral surface of the anterior part of the capitellar lesion. Grade the lesion according to the ICRS classification and evaluate lesion stability with an arthroscopic probe inserted through the anterolateral portal.

Fig. 2

Fig. 2 Set-up position at arthroscopy on the left elbow. The patient is placed in a supine position with the affected arm on the operating room table. A 30° oblique arthroscope is inserted through the anteromedial portal with the elbow flexed 90°. The chondral surface of the proximal part of the capitellum is observed with the elbow flexed 30°.

Step 3: Confirm the Stability of the Lesion

Observe the chondral surface and assess the stability of the lesion by direct observation.

- Place the elbow in a fully flexed position. Make a 4-cm posterolateral oblique straight skin incision line from the posterior edge of the lateral epicondyle to the posterior aspect of the radioulnar joint (Fig. 3-A).
- After inflating the tourniquet, incise the skin and fascia along the skin incision line with a scalpel. Divide the intermuscular plane between the extensor carpi ulnaris and the anconeus muscle (Kocher interval).
- Incise the joint capsule just over the capitellar OCD lesion and explore the radioulnar joint. Excise the local synovitis under the capsule and secure an adequate visual field to expose the lesion under direct vision (Fig. 3-B). Separate the posterior half of the lateral collateral ligament from the lateral epicondyle and move the radial head to visualize the anterior or lateral part of the lesion if the radial head or lateral collateral ligament obstructs the field to explore the whole lesion (Fig. 3-C).
- Assess the entire capitellar lesion by direct observation, confirm lesion stability with an arthroscopic probe, and grade the lesion according to the ICRS classification. Stable lesions with a continuous but softened area covered by visually and elastically normal cartilage are classified as ICRS OCD I, whereas those with partial discontinuity that are stable when probed are classified as ICRS OCD II.

Fig. 3-A

Fig. 3-B

Fig. 3-C

Fig. 3-A Incision line drawing on a cadaveric right elbow. The left oblique line for approaching the lesion is 4 cm in length. The right longitudinal line for graft harvesting from the olecranon (O) is 3 cm in length. RH = radial head and C = capitellum.

Fig. 3-B Visualizing the capitellar lesion directly to survey the chondral surface and assess the stability of the lesion. This case was classified as ICRS OCD II. RH = radial head and C = capitellum.

Fig. 3-C The posterior half of the lateral collateral ligament was separated from the lateral epicondyle in this case. The lesion extends from the lateral to the central portion of the capitellum (C), and it is necessary to expose the lateral wall of the capitellum to perform BPG. This case was classified as ICRS OCD II. RH = radial head and C = capitellum.

Step 4: Harvest and Shape the Bone Pegs

Carefully harvest 3, 4, or 5 bone pegs of approximately 20 mm in length, 2 mm in diameter at the tip, and 3 mm in diameter at the head from the cortex of the ipsilateral olecranon (Video 1).

- Make another skin incision of 3 cm in length at the posterior aspect of the metaphysis of the ipsilateral olecranon with a scalpel.
- Separate the extensor carpi ulnaris muscle and the flexor carpi ulnaris muscle to expose the posterior and medial sides of the cortex of the proximal part of the ulna. Be careful not to disturb the proximal growth plate at the ulna or damage the ulnar nerve.
- Outline a rectangle measuring 20 × 10 mm on the posterior and the medial cortex of the ulna. Then drill the 4 corners of the rectangle with a 1-mm-diameter Kirschner wire.
- Cut the longitudinal and oblique lines for the required number of bone pegs to be approximately 2 mm in diameter at the tip and 3 mm in diameter at the head within the outlined rectangle using a micro-bone saw (Fig. 4-A). Then cut the transverse shorter ends of the rectangle.
- Carefully harvest bone pegs of approximately 20 mm in length from the cortex with a flat chisel. A similar procedure is performed on the lateral side of the cortex of the ulna in cases requiring >4 bone pegs.
- Shave the bone pegs into sharp and smooth pyramid-like shapes (Fig. 4-B).

Fig. 4-A

Fig. 4-B

Fig. 4-A Harvesting bone pegs from the olecranon cortex with a micro-bone saw and chisel.

Fig. 4-B Bone pegs of approximately 20 mm in length are shaved into sharp and smooth pyramid-like shapes.

Video 1 Cadaver demonstration of harvesting bone pegs from the olecranon cortex.

Step 5: Finalize the Site, Direction, and Depth of the Holes for BPG

Make the holes for BPG according to preoperative planning.

- Arrange hole sites to be spaced roughly 5 mm apart.
- Drill each hole to approximately 25 mm in depth with a 3-mm-diameter Kirschner wire instead of a drill to protect the cartilage from excessive shearing stress.
- Obtain anteroposterior and lateral radiographs after the first Kirschner wire is inserted. The site, direction, and depth of the bone pegs should be confirmed. Count the number of required bone pegs.
- If the lesion exhibits instability during probing, it should be classified as ICRS OCD III, and autologous osteochondral grafting rather than BPG should be performed.

Step 6: Fix the Lesion to the Osseous Floor with the Bone Pegs

Insert the bone pegs into the holes and advance them by placing a flat-surfaced rod on the head of each peg and tapping it with a mallet (Video 2).

- Insert the bone pegs into the holes with tweezers to a depth of 10 mm (Fig. 5-A). Place a flat-surfaced rod on the head of the bone peg and advance it by gentle tapping with a mallet.
- Drive the bone-peg heads to a depth slightly lower than the articular cartilage surface, aiming to stabilize the subchondral plate and osseous fragment to the osseous floor (Fig. 5-B).
- Do not invade the annular ligament during the procedures.

Fig. 5-A

Fig. 5-B

Fig. 5-A Bone peg insertion.

Fig. 5-B The bone pegs are driven to a depth slightly lower than the articular cartilage surface. (Reproduced, with permission of SAGE Publications, from: Oshiba H, Itsubo T, Ikegami S, Nakamura K, Uchiyama S, Kato H. Results of bone peg grafting for capitellar osteochondritis dissecans in adolescent baseball players. *Am J Sports Med.* 2016 Dec;44[12]:3171-8.)

Video 2 Cadaver demonstration of drilling holes with a 3-mm-diameter Kirschner wire and insertion of bone pegs.

Step 7: Closure

Close the wound.

- Deflate the tourniquet, irrigate the elbow joint with saline solution, and coagulate the bleeding.
- Securely repair the collateral ligament if it was separated. Leave open the incised joint capsule and suture the fascia of the extensor carpi ulnaris and anconeus firmly.
- Suture the subcutaneous tissue and skin.

Step 8: Postoperative Management

The elbow is immobilized for 3 weeks, and rehabilitation is started; throwing is resumed slowly 6 months after BPG.

- Immobilize the elbow joint in a plastic cast at 90° of flexion for 3 weeks. Allow forearm rotation a couple of days after the surgery and allow active and assisted passive range-of-motion exercises after removal of the cast.
- We have never encountered a complication at the olecranon harvest site for the bone pegs, which is immobilized in a plaster cast for 3 weeks. In addition, the patient is not allowed to use the elbow vigorously for 3 months. During this resting period, the olecranon defect becomes repaired spontaneously with a slight residual cortical dent.
- The patient may resume throwing short distances at a low velocity 6 months after the operation and gradually build up to preinjury levels of competitive baseball performance between 8 and 12 months postoperatively.
- Evaluate the patient at 6, 12, and 24 months after surgery. Make lateral and tangential radiographs and MRIs at each follow-up visit to confirm continuity of the bone peg shadow and the size of lesion.

Results

Between 2004 and 2012, we performed BPG on 11 male adolescent baseball players with capitellar OCD classified as ICRS OCD I or II¹¹. No improvement had been seen during a 6-month period during which they had abstained from throwing. All patients underwent physical, radiographic, and MRI evaluations at 12 and 24 months after surgery. We observed no postoperative complications such as infection, neurological problems, fracture, or contracture. Of the 11 patients, 10 could return to playing baseball at an ability level comparable with their preinjury level within 12 months after the BPG. The mean Timmerman-Andrews score¹³ improved significantly from 171.8 preoperatively to 192.3 at the final observation ($p < 0.01$). As judged radiographically, healing of the lesion was complete in 8 patients and partial in 3 (Fig. 6). Patients with a centrally positioned lesion or a lesion that was <75% of the size of the capitellum had a stronger tendency to demonstrate complete healing on radiographs. Growth plate status appeared unrelated to outcome. The mean Henderson MRI score¹⁴ improved from 6.3 at 12 months to 4.8 at 24 months after the BPG. MRI findings suggested that integration of the grafted site continued until at least 24 months postoperatively (Fig. 7).

Fig. 6

Fig. 7

Figs. 6-A, 6-B, and 6-C A lesion that demonstrated complete healing on tangential anteroposterior radiographs. (Reproduced, with permission of SAGE Publications, from: Oshiba H, Itsubo T, Ikegami S, Nakamura K, Uchiyama S, Kato H. Results of bone peg grafting for capitellar osteochondritis dissecans in adolescent baseball players. *Am J Sports Med.* 2016 Dec;44[12]:3171-8.) **Fig. 6-A** Preoperative radiograph showing the lesion with a translucent cystic shadow and without a split line located from the lateral to the central portion of the capitellum. **Fig. 6-B** Immediately after grafting with 3 bone pegs. **Fig. 6-C** Postoperative radiograph at 24 months demonstrating complete healing of the lesion.

Figs. 7-A, 7-B, and 7-C Oblique-sagittal T2-weighted fast-spin-echo MRI of an elbow that eventually exhibited complete healing. (Reproduced, with permission of SAGE Publications, from: Oshiba H, Itsubo T, Ikegami S, Nakamura K, Uchiyama S, Kato H. Results of bone peg grafting for capitellar osteochondritis dissecans in adolescent baseball players. *Am J Sports Med.* 2016 Dec;44[12]:3171-8.) **Fig. 7-A** Preoperative MRI showing a normally shaped capitellum with several spotted areas of higher signal intensity compared with that of cartilage (stage 3 according to the Itsubo MRI classification). **Fig. 7-B** MRI at 12 months postoperatively. The signal of the grafted bone peg remains. **Fig. 7-C** MRI at 24 months postoperatively demonstrating integration of the bone peg.

Pitfalls & Challenges

- Determine the indication for BPG with radiographs, T2-weighted MRI, arthroscopy, and direct observation.
- BPG is not indicated when the lesion is separated by a high-intensity line on T2-weighted MRI.
- Even when the lesion is seen to have continuity with the osseous floor on radiographs or MRI, BPG is not advised if slight instability is detected by probing under arthroscopy or direct vision.
- Decide the site, length, and direction of bone pegs on the basis of radiographs and MRI.
- If preoperative lateral radiographs of the elbow in full flexion indicate that the lesion is covered by the radial head, it is easier to explore the lesion and perform BPG after separation of the posterior half of the lateral collateral ligament from the lateral epicondyle. The ligament should be securely repaired after BPG.
- The OCD lesion should be explored comprehensively for size, existence of a fissure on the chondral surface, and existence of cartilage softening by probing. Stability is paramount; if the lesion is unstable on probing, BPG is not indicated.
- The harvested pegs should be shaped into sharp pyramids and be smoothly curved.
- When making the bone peg holes, a Kirschner wire should be used instead of a drill to protect the cartilage from excessive shearing stress.
- Do not allow the patient to return to competitive baseball <8 months following BPG because radiographs showed that bone pegs disappeared gradually until 12 months after surgery and MRI indicated integration of the grafted site until at least 24 months postoperatively.

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