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Osteochondral defects of the upper extremity treated with particulated juvenile cartilage transfer

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Abstract We present the novel use of particulated juvenile cartilage transfer in the upper extremity. Our patient is an active duty solider with an osteochondral defect (OCD) of the capitellum that he sustained after an improvised explosive devise injury to his left elbow.

Keywords Osteochondral defect · Elbow · Particulated juvenile cartilage transfer

Introduction

Post-traumatic arthritis of the upper extremity is a difficult problem to treat in younger patients as they have higher physical demands, activity level, and longer life expectancy. In this population, osteochondral lesions of the upper extremity have initially been treated with open debridement [15], arthroscopic debridement [10–12], microfracture [16], and osteochondral autologous transfer [2, 7, 14]. These techniques have yielded mixed results. While debridement may remove loose bodies and improve mechanical symptoms associated with osteochondral defects (OCDs), the articular surface is not restored. Microfracture addresses the articular surface lesion, but the healing after microfracture is often irregular and with primarily fibrocartilage [3]. In addition, while level I evidence suggests that osteochondral autologous transfer is superior to microfracture in the knee [6], there may be significant donor site morbidity with autologous graft harvesting [8, 9].

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Recently, a new technology has been developed. Osteochondral lesions in the talus [4] and patella [13] have been successfully treated with particulated juvenile cartilage transfer (PJCT). *DeNovo*® NT Graft (DeNovo Natural Tissue Graft; Zimmer, Warsaw, IN) is a particulated juvenile cartilage implant used for the repair of articular cartilage damage. It is intended to provide surgeons with an early-intervention option for articular cartilage repair and cartilage restoration. The advantages include a theoretical greater chondrocyte density than adult tissue, no donor site morbidity, and no allogeneic immune response. The graft is implanted in a single stage procedure with fibrin fixation, and there is no need to harvest a periosteal flap or need to harvest tissue or cells from areas of undamaged cartilage. Until recently, OCD lesions in the upper extremity have not previously been treated with PJCT. Here, we present a novel case of PJCT in the upper extremity.

Case Report

A 28-year-old, active duty male Army combat medic sustained a blast injury from an improvised explosive device. During the explosion, the patient's left elbow was crushed against the side of his armored vehicle. Upon arrival to the tertiary care facility, his chief complaint was of ulnar nerve symptoms and elbow pain. No fractures, lesions, or loose bodies were noted in the initial plain films. He eventually underwent an ulnar nerve transposition for symptomatic ulnar neuritis not relieved by conservative measures. No further treatment was provided to the solider at this time.

On initial presentation at our clinic, 3 years after his last follow-up, his chief complaint was of left elbow pain and stiffness. He had a painful arc of motion and was limited to 18–90° of active motion and 15–105° of passive motion. He had full prono-supination. His elbow was ligamentously stable and the upper extremity was otherwise neurovascularly intact. His initial magnetic resonance imaging (MRI) demonstrated multiple loose bodies with an osteochondral defect of the capitellum that measured 16×15×5 mm (Fig. 1a, b). Treatment options included continued non-operative management, arthroscopic debridement, microfracture, autologous graft, or PJCT. After extensive discussion over multiple visits, he underwent an extensive informed consent. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained. In attempt to affectively treat the articular lesion, limit donor site morbidity, and provide healthy articular cartilage, the patient elected for PJCT.

A standard Kocher approach was then used to gain access to the lateral aspect of the elbow. The lateral ulnar collateral ligament (LUCL) was reflected posteriorly and the anterior aspect of the capitellum was then exposed, achieving optimal visualization of the defect. An anterior and posterior capsular release was performed, followed by an open debridement and loose body removal. The large osteochondral defect of the capitellum was noted and prepared by removing fibrous tissue from defect and achieving a vascular bed for graft placement.

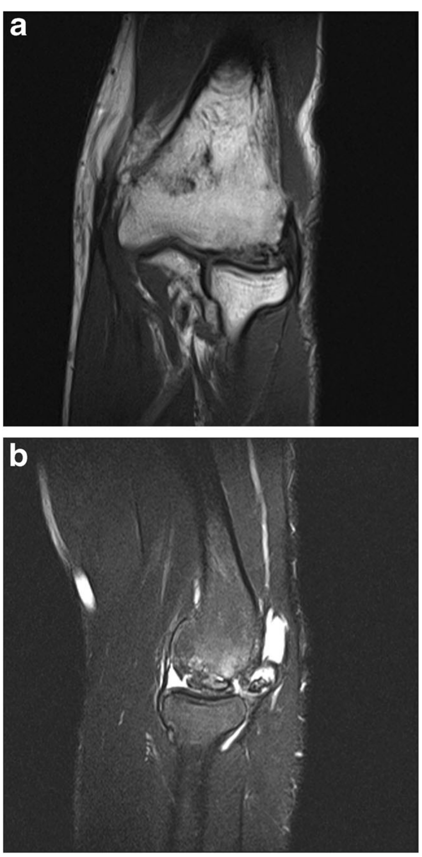

Fig. 1 **a**, **b** Pre-operative coronal and sagittal T2 MRI—demonstrating large capitellum osteochondral defect with loose bodies

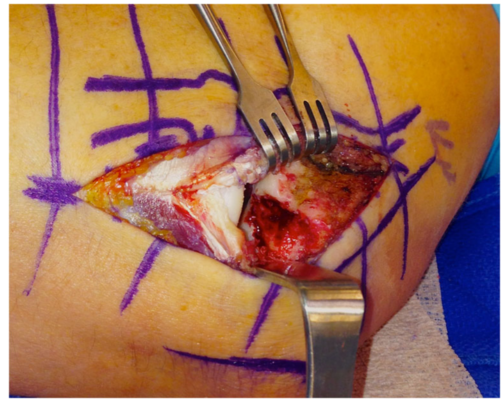

Fig. 2 Intra-operative photo—large capitellum osteochondral defect from Kocher approach. The defect is prepared by creating vertical walls in lesion

The lesion was then curetted to create vertical walls to contain the PJCT graft (Fig. 2). The defect was measured again after preparation to 18×16×6 mm. The PJCT graft was prepared on the back table, using a foil technique to match the defect dimensions, by pressing a free, sterile piece of foil into the defect to create a mold. A layer of fibrin glue (Tisseel, Baxter International Inc., Deerfield, IL) was initially placed into the defect, followed by the prepared graft from the foil mold, and finally a second layer of fibrin glue was applied on the surface to prevent shearing of the graft (Fig. 3). Upon closure of the case, the lateral ulnar collateral ligament was repaired with two suture anchors (Depuy-Mitek, New Brunswick, NJ); the capsule, muscle, subcutaneous tissue, and skin were then closed in a layered fashion.

Post-operatively, the patient was immobilized in a long arm posterior splint with an additional sugar-tong plaster splint for 2 weeks. This was followed by transition to a hinged elbow brace as he progressed to gentle range of motion exercises. The patient progressed in occupational therapy (Table 1). By 4 months post-operatively, the patient began lifting 10 lb without discomfort. At 6 months post-operatively, a repeat MRI demonstrated intact articular cartilage over the capitellum

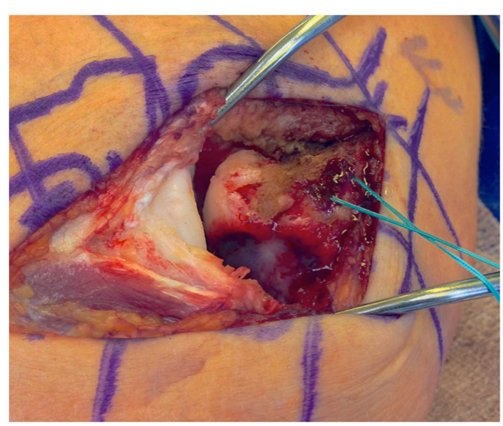

Fig. 3 Intra-operative photo—particulated juvenile cartilage graft in place

Table 1 Occupational therapy course

Time	Pain (1–10) at rest	Pain (1–10) after exercise	Grip strength (affected/unaffected) (lb)	E/F (deg)	OT goals
Pre-op	5	8	Deferred	18/90	Home: given elbow hinge brace AROM as tolerated up to 5/10 pain Edema management: compression sleeve, massage, elevate
2 weeks post	1	3	64/107	18/120	Home: same as previous Clinic: gentle AAROM elbow flexion stretch(×10 min) Elbow brace for protection Hand strengthening
6 weeks post	0	2	91/107	10/120	Home: edema management AA/PROM: active stretch and hold in flexion/passive stretch into extension with gravity assist. 10 min q2 h NWB Clinic: moist heat with gravity assist elbow extension Gentle AA/PROM elbow flex (self-applied)/ext(gravity assist) ×10 min
12 weeks post	0	3	94/107	10/124	Home: PROM into extension weighted stretch 5×/day ×10 min NWB Clinic: same as previous week Increase elbow mobilization, non-resistive ROM
18 weeks post	0	0	94.4/118	10/128	Home: PROM into extension weighted stretch 5×/day ×10 min Open chain exercises with gravity resist Advance to strengthening with band resistance NWB Clinic: same as previous week Light open chain kinetic strengthening with advance to band resistance
22 weeks post	0	0	94.4/118	5/140	Home: same Modified push-up program—starting with wall push-ups and progress to standard. 3 sets of 10 qd Clinic: same Advance push-up program

E/F extension/flexion, *S/P* supination/pronation, *AROM* active range of motion, *AAROM* active assist range of motion, *PROM* passive range of motion, *qd* every day

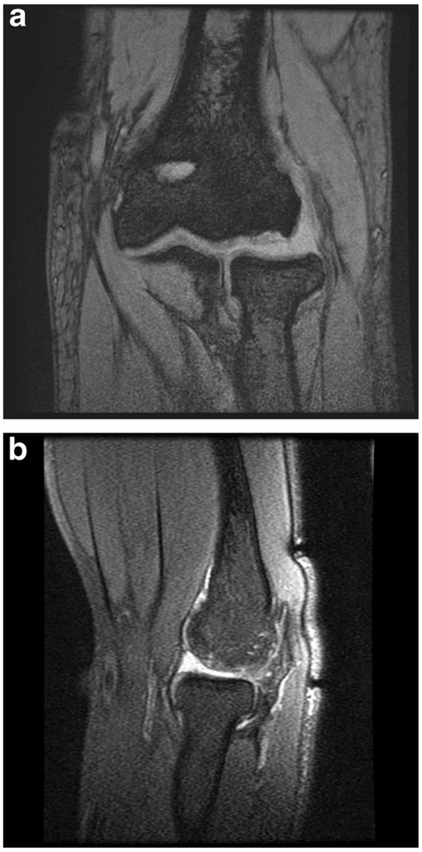

Fig. 4 **a**, **b** Post-operative coronal and sagittal T2 MRI—demonstrating restoration of congruent articular surface

(Fig. 4a, b). At 12 months post-operatively, the patient had significant improvement in subjective outcome scores (Table 2). The patient returned to an active lifestyle with no limitation of elbow function.

Discussion

We preset a novel case of PJCT for a large osteochondral lesion in the upper extremity. PJCT allows for articular surface restoration with hyaline cartilage, in a single stage implantation, and without donor site morbidity. In addition, the exact morphology of the articular surface does not need to be matched by a graft as with autologous graft transfer and the implant is immediately ready which allows for less tourniquet and anesthesia time. The ideal patient for PJCT is a young, active patient with an isolated osteochondral lesion who would benefit from better restoration of the articular surface, without donor site morbidity.

Table 2 Pre and post-operative outcome scores and range of motion

Procedure	Pre MAYO	Pre DASH	Post MAYO	DASH	Pre-extension-flexion	Post-extension-flexion
Capitellum	80	25.8	100	1.7	18–90°	5–140°

Clinical series have supported the use of PJCT in the lower extremity. Previously, PJCT has been described for use in the talus [4] and patella [13]. Coetzee et al. [4] used PJCT on 24 ankles with an average age of 35 years and 16 months of follow-up. The authors found that 92 % of patients with lesions between 10 and 15 mm had a good-excellent outcome. Lesions that were greater than 15 mm had slightly less favorable outcomes. Tompkins et al. [13] used PJCT on 15 patients with an average age of 26 years with follow-up of 29 months. Normal articular cartilage was noted in 73 % of patients on post-operative MRI. Gross graft hypertrophy was found in two patients and arthroscopic debridement was necessary. Clinically, the patients had favorable outcomes with an average post-operative Internal Knee Documentation Committee Evaluation (1–100) of 84 for pain, 85 for stiffness, and 89 for activities of daily living. In addition, the post-operative Visual Analog Score was 1.9. Despite the short series with limited follow-up, the patients in these studies have done well clinically and having promising MRI results. In addition to clinical evidence, Farr et al. [5] evaluated eight PJCT grafts histologically 2 years after implantation. The authors found that type II collagen predominated in the graft samples with excellent graft integration.

PJCT in the upper extremity is a novel procedure for treatment of the post-traumatic osteochondral lesion. Traditionally, these lesions have been treated initially with debridement; however, the articular cartilage defect is left unaddressed. In a review of 33 elbows with an average age of 50 years, 121 months after open debridement, range of motion (ROM) improved 25° and 85 % of patients were satisfied with their result [15]. Debridement can also be completed arthroscopically. In 42 arthritic elbows with an average age of 53 years debrided arthroscopically after 176 weeks, ROM improved 27° and 81 % experienced good to excellent results. For older patients or those with limited physical demands, debridement may be a reasonable first step in the treatment of articular defects [1].

For younger patients with higher functional demands, an attempt at restoration of the articular surface should be made. Wulf et al. [16] analyzed the results of 10 patients with an average age of 14 years, 4.6 months after microfracture for osteochondritis dissecans of the capitellum. The authors found a 25° increase in ROM as well as a 27 point gain in the Mayo score post-operatively. Joint congruity with restoration of the articular surface was noted in 8 of 10. However, of the eight patients which participated in competitive athletics, only six returned to the same level of sport. While no patients in this series experienced donor site morbidity, 25 % were unable to return to sport. In another report, autologous osteochondral transplantation was used in the treatment of eight patients, with an average age of 17 years, with osteochondral defects of the capitellum or radial head. Mean ROM gain was 19° and the all post-operative subjective patient scores improved at 8–14-year follow-up. However, 25 % of the patients in this series were unable to return to sports at 37.5 % of the patients experienced donor site morbidity [14]. Furthermore, in an analysis of seven MRIs after osteochondral defects treated with autologous osteochondral transplantations with an average age of 17 years, all seven elbows demonstrated graft viability and a congruent chondral surface [2].

Post-operative physical therapy and weight bearing restrictions are a delicate balance between graft preservation and joint stiffness. In the ankle, Coetzee et al. [4] made all patients non-weight bearing for 6 weeks post-operatively. In the knee, Tompkins et al. [13] made all patients partial weight bearing locked in extension for 6 weeks. During this time, light range of motion exercises were performed. Jogging was allowed at 3 months with return to sport at 6 months. More cases with longer follow will need to be evaluated before specific physical therapy recommendations are made. However, for the upper extremity, we currently recommend 2 weeks of immobilization followed by light range of motion exercises in a hinged brace. We recommend a total of 3 months of non-weight bearing, in attempt to avoid graft shearing (Table 1).

In conclusion, we present a novel case of PJCT in the upper extremity. At 12 months post-operatively, our patient had significant ROM improvements, pain relief, and restoration of the capitellum articular surface as demonstrated on MRI. Importantly, our patient was retained and returned to full active duty, with no physical limitations. While more cases will need to be collected and followed for long-term analysis, the utilization of PJCT showed a promising result in our patient. This procedure was a natural extension to an unsolved problem from prior successes of osteochondral autologous transfers in the elbow and PJCT in lower extremity cases.

Conflict of Interest John C. Dunn declares that he has no conflict of interest.

Nicholas Kusnezov declares that he has no conflict of interest.

Justin Orr declares that he has no conflict of interest.

Justin S. Mitchell declares that he has no conflict of interest.

Statement of Human and Animal Rights This article does not contain any studies with human or animal subjects.

Statement of Informed Consent No identifying information was used and as such, informed consent is not necessary.

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