Can Extruded Osteoarticular Fracture Fragments Be Decontaminated and Preserved for Delayed Surgical Reimplantation?

Rown Parola[1], Gregory John Della Rocca[2], Aaron Michael Stoker[3], Julia Vetter Nuelle, Chantelle Bozynski, James L Cook[4]
[1]Missouri Orthopaedic Institute, [2]University of Missouri Orthopaedics, [3]University of Missouri Columbia, [4]Univ of Missouri

INTRODUCTION:

Open articular fractures pose a challenge for orthopaedic surgeons. Anatomic reconstruction with autogenous cartilage and bone provides the most consistently successful outcomes; therefore, retention of osteoarticular fracture fragments is desirable. However, these fragments are often contaminated, devascularized, and/or extruded, making standard methods for preservation and reimplantation rarely successful. Current recommendations, therefore, are to discard osteoarticular fracture fragments. This lack of success may be related to difficulty in achieving a safe and effective balance between disinfection and preservation of viability. With recent advances in osteochondral allograft (OCA) preservation, we sought to investigate the potential for OCA preservation methods for effective disinfection and storage of osteoarticular fracture fragments such that delayed reimplantation for functional joint reconstruction could be considered. Using a preclinical captive bolt penetrating trauma model, this study was designed to test the hypothesis that disinfection followed by storage using the Missouri Osteochondral Preservation System (MOPS) will allow for effective decontamination while retaining viable chondrocytes in extruded osteoarticular fracture fragments for up to 14 days after recovery.

METHODS:

Purpose-bred hounds (n=16) were humanely euthanized (for purposes unrelated to the study), immediately after which an open articular fracture in both elbows (n=32) was created using a captive bolt pistol. Soft tissues were removed aseptically and the distal humerus (n=32), proximal radius (n=32), and trochlea (n=32) were osteotomized and processed under operating room conditions in 1 of 3 ways: Betadine (n=40): 0.9% saline irrigation (1L), 10% povidone-iodine solution immersion (20 min), saline irrigation; Chlorhexidine (n=42): saline irrigation, 0.002% chlorhexidine solution immersion (20 min), saline irrigation; Control (n=12): untreated. Each osteoarticular fragment was placed in MOPS (200ml) in a sterile container and stored under standard room temperature and humidity conditions for 7 (n=46) or 14 (n=48) days. At each timepoint, we assayed viable chondrocyte density (VCD) and quantitative microbial culture assessments, yielding a count of colony forming units (CFU) per specimen. Univariate comparison of VCD and CFU were performed via Kruskal-Wallis and Chi-squared test. We used multivariate linear regression, controlling for osteotomy site and storage time, to determine the correlation between processing method and VCD or CFU. Data manipulation and statistical analysis were performed.

RESULTS:

Captive bolt penetrating trauma achieved Gustilo-Anderson type III open distal humeral, proximal radial, and trochlear fractures in each elbow. Control, betadine, and chlorhexidine treatment resulted in differing distribution of VCD and CFU per specimen at 7 and 14 days (Table 1). On multivariate analysis with independent variables of treatment group, storage timing, and osteotomy site, treatment with betadine correlated with a decrease of 187 VCD ($p = 0.02$) relative to control treatment and treatment with chlorhexidine correlated with an increase of 377 VCD ($p < 0.001$) relative to control treatment. When controlling for osteotomy site and storage timing, treatment with betadine correlated with a decrease of 18.4×10^6 CFU ($p < 0.001$) relative to control treatment and treatment with chlorhexidine correlated with a decrease of 15.8×10^6 CFU ($p < 0.001$) relative to control treatment. Fourteen days of storage correlated with a decrease of 187 VCD relative to 7 days of storage ($p < 0.001$) and an increase of 4.8×10^6 CFU at 14 days of storage relative to 7 days of storage when controlling for treatment group and osteotomy site.

DISCUSSION AND CONCLUSION:

A treatment protocol combining saline irrigation with 0.002% chlorhexidine immersion followed by room temperature storage in MOPS was effective for decontaminating osteoarticular fracture fragments while maintaining chondrocyte viability for up to 14 days after penetrating trauma. Contaminated, devascularized, extruded articular fracture fragments can be retained and stored for use as osteoarticular autografts such that delayed reimplantation for functional joint reconstruction could be considered.

Table 1: Univariate statistics

Storage time, days		Control (N=12)	Betadine (N=40)	Chlorhexidine (N=42)	Total (N=94)	p value
7	**Location, n (%)**					0.992
	Distal Humerus	2 (33.3%)	7 (36.8%)	7 (33.3%)	16 (34.8%)	
	Radial Head	2 (33.3%)	7 (36.8%)	7 (33.3%)	16 (34.8%)	
	Trochlea	2 (33.3%)	5 (26.3%)	7 (33.3%)	14 (30.4%)	
	Viable Chondrocyte Density, mean (SD), mm^{-2}	603.0 (280.4)	293.2 (184.1)	772.3 (257.0)	552.3 (320.8)	< 0.001
	Colony Forming Units, mean (SD), 10^6 per specimen	19.8 (29.8)	0.2 (0.5)	0.4 (1.8)	2.9 (12.1)	< 0.001
14	**Location, n (%)**					1.000
	Distal Humerus	2 (33.3%)	7 (33.3%)	7 (33.3%)	16 (33.3%)	
	Radial Head	2 (33.3%)	7 (33.3%)	7 (33.3%)	16 (33.3%)	
	Trochlea	2 (33.3%)	7 (33.3%)	7 (33.3%)	16 (33.3%)	
	Viable Chondrocyte Density, mean (SD), mm^{-2}	125.2 (117.9)	62.3 (71.5)	709.5 (338.0)	353.3 (391.7)	< 0.001
	Colony Forming Units, mean (SD), 10^6 per specimen	20.1 (16.9)	3.3 (6.7)	7.9 (14.2)	7.4 (12.8)	0.003