

# World Journal of *Orthopedics*

*World J Orthop* 2021 November 18; 12(11): 811-960



**OPINION REVIEW**

- 811 Revisiting Pauwels' classification of femoral neck fractures  
*Nandi S*

**ORIGINAL ARTICLE****Case Control Study**

- 816 Paraspinal strength and electromyographic fatigue in patients with sub-acute back pain and controls: Reliability, clinical applicability and between-group differences  
*Koumantakis GA, Oldham JA*

**Retrospective Cohort Study**

- 833 Preseason elimination impact on anterior cruciate ligament injury in the National Football League  
*Patetta M, Mayo B, Martini OZ, Sullivan B, Onsen L, Hutchinson M*

**Retrospective Study**

- 842 Risk of methicillin-resistant staphylococcus aureus prosthetic joint infection in elective total hip and knee arthroplasty following eradication therapy  
*Kapur BP, Tonge X, Kumar G*

- 850 Reliability of a simple fluoroscopic image to assess leg length discrepancy during direct anterior approach total hip arthroplasty  
*Caus S, Reist H, Bernard C, Blankstein M, Nelms NJ*

- 859 Anthropometric method for estimating component sizes in total hip arthroplasty  
*Sahemey R, Moores TS, Meacher H, Youssef B, Khan S, Evans CR*

- 867 Treatment of knee osteochondritis dissecans with autologous tendon transplantation: Clinical and radiological results  
*Turhan AU, Açıl S, Gül O, Öner K, Okutan AE, Ayas MS*

**Clinical Trials Study**

- 877 Direct anterior approach *vs* Hardinge in obese and nonobese osteoarthritic patients: A randomized controlled trial  
*Macheras G, Stasi S, Sarantis M, Triantafyllou A, Tzeffronis D, Papadakis SA*

**Observational Study**

- 891 Work-related musculoskeletal injuries among upper extremity surgeons: A web-based survey  
*Alzahrani MM, Alqahtani SM, Pichora D, Bicknell R*

**EVIDENCE-BASED MEDICINE**

- 899 Implementation science for the adductor canal block: A new and adaptable methodology process  
*Crain N, Qiu CY, Moy S, Thomas S, Nguyen VT, Lee-Brown M, Laplace D, Naughton J, Morkos J, Desai V*

**SYSTEMATIC REVIEWS**

- 909 Femoral lengthening in young patients: An evidence-based comparison between motorized lengthening nails and external fixation  
*Hafez M, Nicolaou N, Offiah AC, Giles S, Madan S, Fernandes JA*

**META-ANALYSIS**

- 920 Role of coatings and materials of external fixation pins on the rates of pin tract infection: A systematic review and meta-analysis  
*Stoffel C, Eltz B, Salles MJ*

**CASE REPORT**

- 931 Allergic dermatitis after knee arthroscopy with repeated exposure to Dermabond Prineo™ in pediatric patients: Two case reports  
*Robinson J, Smidt KP, Houk G, McKie J, Barton RS, Massey P*
- 938 Pathological humerus fracture due to anti-interferon-gamma autoantibodies: A case report  
*Yang CH, Kuo FC, Lee CH*
- 945 Spontaneous pneumothorax in a 17-year-old male patient with multiple exostoses: A case report and review of the literature  
*Nakamura K, Asanuma K, Shimamoto A, Kaneda S, Yoshida K, Matsuyama Y, Hagi T, Nakamura T, Takao M, Sudo A*
- 954 Management of acute length-unstable Monteggia fractures in children: A case report  
*Evola FR, Di Fede GF, Bonanno S, Evola G, Cucuzza ME*

**ABOUT COVER**

Editorial Board Member of *World Journal of Orthopedics*, Christiaan JA van Bergen, MD, PhD, Senior Researcher, Surgeon, Department of Orthopaedic Surgery, Amphia, Breda 3000, Netherlands. [cvanbergen@amphia.nl](mailto:cvanbergen@amphia.nl)

**AIMS AND SCOPE**

The primary aim of *World Journal of Orthopedics* (*WJO*, *World J Orthop*) is to provide scholars and readers from various fields of orthopedics with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

*WJO* mainly publishes articles reporting research results and findings obtained in the field of orthopedics and covering a wide range of topics including arthroscopy, bone trauma, bone tumors, hand and foot surgery, joint surgery, orthopedic trauma, osteoarthritis, osteoporosis, pediatric orthopedics, spinal diseases, spine surgery, and sports medicine.

**INDEXING/ABSTRACTING**

The *WJO* is now abstracted and indexed in PubMed, PubMed Central, Emerging Sources Citation Index (Web of Science), Scopus, China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (CSTJ), and Superstar Journals Database. The 2021 edition of Journal Citation Reports® cites the 2020 Journal Citation Indicator (JCI) for *WJO* as 0.66. The *WJO*'s CiteScore for 2020 is 3.2 and Scopus CiteScore rank 2020: Orthopedics and Sports Medicine is 87/262.

**RESPONSIBLE EDITORS FOR THIS ISSUE**

Production Editor: *Lin-YuTong Wang*; Production Department Director: *Xiang Li*; Editorial Office Director: *Jim-Lai Wang*.

**NAME OF JOURNAL**

*World Journal of Orthopedics*

**ISSN**

ISSN 2218-5836 (online)

**LAUNCH DATE**

November 18, 2010

**FREQUENCY**

Monthly

**EDITORS-IN-CHIEF**

Massimiliano Leigheb

**EDITORIAL BOARD MEMBERS**

<http://www.wjgnet.com/2218-5836/editorialboard.htm>

**PUBLICATION DATE**

November 18, 2021

**COPYRIGHT**

© 2021 Baishideng Publishing Group Inc

**INSTRUCTIONS TO AUTHORS**

<https://www.wjgnet.com/bpg/gerinfo/204>

**GUIDELINES FOR ETHICS DOCUMENTS**

<https://www.wjgnet.com/bpg/GerInfo/287>

**GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH**

<https://www.wjgnet.com/bpg/gerinfo/240>

**PUBLICATION ETHICS**

<https://www.wjgnet.com/bpg/GerInfo/288>

**PUBLICATION MISCONDUCT**

<https://www.wjgnet.com/bpg/gerinfo/208>

**ARTICLE PROCESSING CHARGE**

<https://www.wjgnet.com/bpg/gerinfo/242>

**STEPS FOR SUBMITTING MANUSCRIPTS**

<https://www.wjgnet.com/bpg/GerInfo/239>

**ONLINE SUBMISSION**

<https://www.f6publishing.com>

## Retrospective Study

## Treatment of knee osteochondritis dissecans with autologous tendon transplantation: Clinical and radiological results

Ahmet Uğur Turhan, Sezgin Açıl, Orkun Gül, Kerim Öner, Ahmet Emin Okutan, Muhammet Salih Ayas

**ORCID number:** Ahmet Uğur Turhan 0000-0002-2031-6104; Sezgin Açıl 0000-0002-1751-7642; Orkun Gül 0000-0001-6690-2689; Kerim Öner 0000-0001-8415-1057; Ahmet Emin Okutan 0000-0003-1818-9422; Muhammet Salih Ayas 0000-0002-7427-2223.

**Author contributions:** Ayas MS, Turhan AU, Açıl S, Gül O, Öner K and Okutan AE designed the research study; Ayas MS, Turhan AU, Açıl S, Gül O, Öner K and Okutan AE performed the research, analyzed the data and wrote the manuscript; All authors have read and approve the final manuscript.

**Institutional review board**

**statement:** This study was approved by the institutional review board of our hospital.

**Informed consent statement:**

Patients were not required to give informed consent to the study because the analysis used anonymous clinical data that were obtained after each patient agreed to treatment by written consent.

**Conflict-of-interest statement:** The authors declare that there are no conflicts of interest.

**Data sharing statement:** The participants gave informed consent

**Ahmet Uğur Turhan, Kerim Öner,** Department of Orthopedics and Traumatology, Karadeniz Technical University Faculty of Medicine, Trabzon 61080, Turkey

**Sezgin Açıl,** Department of Orthopedics and Traumatology, Tirebolu State Hospital, Giresun 28100, Turkey

**Orkun Gül,** Department of Orthopedics and Traumatology, Medical Park Trabzon Hospital, Trabzon 61080, Turkey

**Ahmet Emin Okutan,** Department of Orthopedics and Traumatology, Samsun Training and Research Hospital, Samsun 55100, Turkey

**Muhammet Salih Ayas,** Department of Orthopedics and Traumatology, Erzurum Regional Training and Research Hospital, Erzurum 25070, Turkey

**Corresponding author:** Muhammet Salih Ayas, MD, Assistant Professor, Doctor, Department of Orthopedics and Traumatology, Erzurum Regional Training and Research Hospital, Çat Yolu Cad., Erzurum 25070, Turkey. [muhammetsalihayas@yahoo.com.tr](mailto:muhammetsalihayas@yahoo.com.tr)

**Abstract****BACKGROUND**

Defect treatment with tendon autograft in osteochondral lesions has been published in the literature with an experimental study in dogs. To demonstrate that it is possible to treat knee osteochondral lesions with the technique of autologous tendon transplantation.

**AIM**

To evaluate the clinical and radiological results of patients with knee osteochondral lesions who were treated with autologous tendon transplantation.

**METHODS**

Twenty patients (22 knees) with osteochondritis dissecans (OCD) lesions involving the knee were treated with autologous tendon transplantation between 2005-2018. All lesions were International Cartilage Repair Society grade IV. All patients were evaluated clinically at final follow-up with knee injury and osteoarthritis outcome score (KOOS); and radiologically with magnetic resonance observation and cartilage repair tissue (MOCART) and Kellgren-Lawrence (KL) classification.

for data sharing.

**Country/Territory of origin:** Turkey

**Specialty type:** Orthopedics

**Provenance and peer review:**

Unsolicited article; Externally peer reviewed

**Peer-review report's scientific quality classification**

Grade A (Excellent): 0

Grade B (Very good): B, B

Grade C (Good): 0

Grade D (Fair): 0

Grade E (Poor): 0

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

**Received:** June 17, 2021

**Peer-review started:** June 17, 2021

**First decision:** July 28, 2021

**Revised:** July 28, 2021

**Accepted:** September 16, 2021

**Article in press:** September 16, 2021

**Published online:** November 18, 2021

**P-Reviewer:** Shetty UC, Zabrzynski J

**S-Editor:** Ma YJ

**L-Editor:** A

**P-Editor:** Wang LYT



## RESULTS

A total of 20 patients (22 knees) with a mean age of  $25.5 \pm 6.8$  years were included. The average defect size was  $4.2 \pm 2.1$  cm<sup>2</sup>, and the average defect depth was  $0.9 \pm 0.4$  cm. Total KOOS score was preoperatively  $29.4 \pm 5.5$  and was later found to be  $81.5 \pm 5.9$  after an average of  $68.7 \pm 37.7$  mo follow-up. The mean MOCART score was  $56.2 \pm 10.7$ . Preoperatively, all of the patients had KL grades of 0–1; during the follow-up period, 80% of the patients showed no radiological progress of osteoarthritis. Patients with less than 4 cm<sup>2</sup> lesion had statistically significantly better overall KOOS than patients whose more than 4 cm<sup>2</sup> lesion, particularly in sport and quality of life subscales.

## CONCLUSION

The autologous tendon transplantation is a single-step, safe, simple, cost-effective method for the treatment of knee OCD with satisfactory clinical and radiological outcomes, particularly in patients with less than 4 cm<sup>2</sup> lesion.

**Key Words:** Osteochondritis dissecans; Knee; Tendon; Transplantation; Autologous; Peroneus

©The Author(s) 2021. Published by Baishideng Publishing Group Inc. All rights reserved.

**Core Tip:** Defect treatment with tendon autograft in osteochondral lesions has been published in the literature with an experimental study in dogs. However, to date, only one case in the capitellum of the elbow has been scientifically published in humans. This retrospective study shows that knee osteochondral lesions are possible with tendon autograft transplantation technique.

**Citation:** Turhan AU, Açıl S, Gül O, Öner K, Okutan AE, Ayas MS. Treatment of knee osteochondritis dissecans with autologous tendon transplantation: Clinical and radiological results. *World J Orthop* 2021; 12(11): 867-876

**URL:** <https://www.wjgnet.com/2218-5836/full/v12/i11/867.htm>

**DOI:** <https://dx.doi.org/10.5312/wjo.v12.i11.867>

## INTRODUCTION

Knee osteochondritis dissecans (OCD) is a common pathology affecting the articular cartilage and resulting in the delamination of subchondral bone[1,2]. The exact causes are unknown, however, biological (ischemia, osteonecrosis) and mechanical factors (trauma, overuse) has been proposed[3,4]. The OCD can cause a very wide range of clinical presentation from completely asymptomatic to functional impairment. If left untreated, these lesions may lead to the development of osteoarthritis[5].

The management of OCD in young patients who may not be good candidates for arthroplasty remains a challenge for the knee surgeons. Many treatments have been proposed including fragment fixation, microfracture, osteochondral autograft / allograft transplantation, matrix-induced chondrogenesis, and autologous chondrocyte implantation, depending on the size and depth of lesion[6,7]. The purpose of any surgical interventions is to re-establish the joint surface, provide the joint congruency, relieve the symptoms and decrease the risk of degenerative osteoarthritis. The numerous number of treatment options reveals the challenge of the management of knee OCD. However, the real challenge being to choose the 'most rational' of several alternative options which potentially differing in their outcomes.

Osteochondral autograft transplantation and mosaicplasty are common surgical procedures for treating symptomatic International Cartilage Repair Society (ICRS) grade 3 or 4 defects smaller than 3 cm<sup>2</sup>[8]. These techniques has several advantages including resurface the defect with normal cartilage and replace concurrently the subchondral bone. But, the donor site morbidity is a major disadvantage. Furthermore, obtaining a congruent surface with donor grafts requires technically challenging skill [9]. To address these problems, we have proposed a new graft source, the peroneus longus tendon, hypothesizing that the tendon autograft with elastic structure can enable

easily joint congruence and with solid structure can provide early weight-bearing. Encouraged by the success of tendon autograft in a dog model[10], the technique was applied in a series of 20 patients with a OCD.

The purpose of this study is to retrospectively evaluate the clinical and radiological results of autologous tendon transplantation using the peroneus longus tendon in patients with ICRS grade 3 or 4 defects.

## MATERIALS AND METHODS

This study was approved by the institutional review board of our hospital. Patients were retrospectively followed up for a minimum of 2 years and data were evaluated retrospectively. Twenty-two consecutive knees (20 patients, 2 bilateral) who underwent autologous tendon transplantation for knee OCD were enrolled from 2005 to 2018. The inclusion criteria for the treatment were (1) Patients with osteochondral defects graded IV on ICRS (International Cartilage Repair Society) classification; (2) Patients with a OCD lesions located at the femoral condyles, sized more than 2 cm<sup>2</sup>, causing knee symptoms (pain, swelling or locking) and lesions were not suitable for fixation; and (3) Patients who failed a conservative treatment at least 6-mo period. The exclusion criteria were (1) Kellgren and Lawrence grade  $\geq 2$  osteoarthritis; (2) Osteonecrosis and inflammatory arthropathy; (3) Meniscal deficiency or ligament instability; (4) Patients with other general medical conditions (*e.g.*, diabetes mellitus or rheumatoid arthritis); (5) Multiple and recent intra-articular injections with steroids; (6) Deformity or OA at ipsilateral and contralateral hip or ankle joints; and (7) Possible non-compliance to the proposed rehabilitation protocol.

Preoperatively, all patients underwent a thorough physical examination, including knee passive and active range of motion, ligamentous stability and knee specific tests. Standard radiography were acquired in every patient to evaluate the osteochondral lesions and knee osteoarthritis. The magnetic resonance images (MRI) were obtained routinely to evaluate the size and depth of the OCD lesion. Patients were assessed with Knee Injury and Osteoarthritis Outcome Score (KOOS) before the operation and at the final follow-up. The radiological outcomes were assessed with magnetic resonance observation of cartilage repair tissue (MOCART) score and with Kellgren-Lawrence (KL) classification.

The osteochondral defect repair was radiologically evaluated by MRI using the Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART). Images were evaluated according to defect filling, integration into the border region, surface of the repair tissue, structure of the repair tissue, signal intensity of the repair tissue, subchondral lamina status, integrity of the subchondral bone, and joint adhesion and infusion[11]. Integrity assessment of the subchondral bone could not be made because the defect area was restored with autologous tendon in the treatment procedure. Therefore, the score ranged from 0 (worst result) to 90 (best possible result).

MRI was performed on a 1.5 Tesla system (Avanto; Siemens Medical Solution, Erlangen, Germany) using ankle coil. The following sequences with axial, coronal and sagittal plains were used: T1-weighted turbo spin echo (T1W TSE) [TR/TE = 777/12 ms, matrix = 320 x 224, field of view (FOV) = 16 cm, excitations = 1, slice thickness = 3 mm, spacing = 0.6 mm], fat saturated proton density weighted turbo spin echo (PDW TSE FS) (TR/TE = 3330/47 ms, matrix = 320 x 224, FOV = 16 cm, excitations = 1, slice thickness = 4 mm, spacing = 1.2 mm), and fat saturated T2-weighted turbo spin echo (T2 TSE FS) (TR/TE = 5200/75 ms, matrix = 208 x 256, FOV = 16 cm, excitations = 1, slice thickness = 4 mm, spacing = 1.2 mm).

KOOS is a specific questionnaire form about the knee containing 42 questions in 5 individual subheadings. These 5 subgroups are: pain, symptoms, activities of daily living, sports and quality of life. KOOS is a recommended scoring system in cartilage repair patients and is a reliable test being used in patients after their surgical treatments of focal cartilage lesions in recent years[12].

### Surgical technique

All procedures were performed in a supine position under general or spinal anesthesia and a thigh tourniquet was applied. A diagnostic arthroscopy was performed, intra-articular conditions were evaluated, associated meniscal injuries were treated and any loose bodies were removed. A mini-arthrotomy was used, depending on the size and site of the lesion. The osteochondral lesion was removed and debrided until viable bleeding bone was reached. The subchondral bone was drilled at 2-4 mm intervals with 1 mm thick K-wire. Following this, a longitudinal posterolateral mini-incision

was opened over the peroneus longus tendon, 10 cm proximal to the lateral malleolus on the ipsilateral side. A split portion of tendon was harvested from the peroneus longus. The graft was folded back on itself and held with absorbable suture, creating a “ball” and then fixed into the defect with suture anchor (Figure 1). The spherical congruency of the joint was checked. Finally, a cylindrical cast or orthosis was applied at 15 degrees of knee flexion.

Post-operative follow-up; Immediate isometric quadriceps exercise was started postoperatively. All patients were mobilized with weight-bearing on postoperative day 1. At the end of the 4th week, cylindrical cast was removed and active and passive knee joint movements were prescribed. All patients followed the same rehabilitation protocol for 6 mo, respectively, based on current knowledge of the graft healing biology: protect the transplant from excessive loads and shearing forces, gain full extension and gradual recovery of knee flexion, progressive recovery in daily functional activities, increase the strength of the quadriceps and hamstrings, recovery of full range of motion, further increase in strength of quadriceps and flexors muscles, further increase in functional activities level, prepare athlete for a return to team and competition with good recovery of the aerobic endurance, maintain a good quality of life, avoiding excess of body fat and preventing risk of reinjury.

All patients were followed up in the outpatient clinic at the 2nd week, 4th week, 8th week, 12th week, 6th month, at the end of 1 year and at the last clinical follow-up. Clinical follow-ups; It was performed together with a surgeon and a physiotherapist in the surgical team, and the data were documented at each clinical control.

All patients were evaluated radiologically with MRI at the end of the first year and at the last follow-up. Radiological evaluations were evaluated by 2 independent radiologists in consensus.

### Statistical analysis

The statistical analysis was performed using SPSS Version 22.0 statistical analysis software. Percentage, rate, average and SD were used as descriptive statistics. The compliance of the quantitative data with normal distribution was evaluated using the Kolmogorov-Smirnov test. The parametric data were compared using the Student *t*-test and the nonparametric data were compared using the Mann-Whitney *U* test. *P* value less than 0.05 was considered to be statistically significant.

## RESULTS

Twenty-two knees of 20 patients underwent autologous tendon transplantation who had knee OCD were included in the study. The mean patient age was  $25.5 \pm 6.8$  years (range, 19-42 years) and the follow-up period was  $68.7 \pm 37.7$  mo (range, 30-182 mo). Detailed patients demographics are shown in Table 1.

Preoperatively, the average KOOS score was  $32.2 \pm 5.8$  for pain,  $28.2 \pm 6.4$  for symptom,  $44.5 \pm 8.1$  for activity of daily living,  $22.4 \pm 4.6$  for sport, and  $24.5 \pm 5.8$  for quality of life. Postoperatively, the average KOOS score was  $91.3 \pm 4.2$  for pain,  $89.1 \pm 7.2$  for symptom,  $85.1 \pm 6.8$  for activity of daily living,  $74.5 \pm 7.2$  for sport, and  $72.4 \pm 8.1$  for quality of life. Preoperative total KOOS score was  $29.4 \pm 5.5$  (range, 21.4-40.5). KOOS total score was found to be increased to  $81.5 \pm 5.9$  (range, 74.2-92.7). All parameters of the KOOS score improved significantly ( $P < 0.001$ ) (Table 2).

The mean MOCART score was found  $56.2 \pm 10.7$  (range, 40-75) at last follow-up. There was no significant correlation between the total MOCART and KOOS scores. Preoperatively, all of the patients had Kellgren-Lawrence grades of 0-1; during the follow-up period, 80% ( $n = 16$ ) of the patients no showed radiographical progression of osteoarthritis (Figure 2). Patients with less than 4 cm<sup>2</sup> lesion had statistically significantly better overall KOOS ( $P < 0.01$ ) than patients whose more than 4 cm<sup>2</sup> lesion. In terms of the KOOS subscales, however, this was true only with sport ( $P = 0.01$ ) and quality of life ( $P = 0.02$ ). There were no statistically significant differences in the subscales pain, symptoms and activity of daily living (Figure 3).

Second-look arthroscopy was performed during contralateral knee operation to the patients who was operated from both knees at one year intervals. Second look arthroscopy view at 1-year follow-up of ICRS grade 4 of medial femoral condyle showing filling of the defect with a well-integrated, smooth surfaced and stable regenerated cartilage. The graft adaptation and incorporation were assessed to be excellent (Figure 4).

Peroneus longus tendons were used as autologous grafts in all patients. No complications developed in any patient regarding donor site. In the graft donor site, no patient

**Table 1 Demographic characteristics of patients**

Age at time of surgery, yr, mean $\pm$ SD (range)	25.5 $\pm$ 6.8 (19-42)
Sex, M/F, n (%)	15 (75%)/5 (25%)
BMI, kg/cm <sup>2</sup> , mean $\pm$ SD (range)	27.1 $\pm$ 3.5 (21.6-32.4)
Side, R/L, n (%)	13 (59.9%)/9 (40.1%)
Location, MFC/LFC, n (%)	18 (81.8%)/4 (18.2%)
Size, cm <sup>2</sup> , mean $\pm$ SD (range)	4.2 $\pm$ 2.1 (2.1-9.0)
Depth, cm, mean $\pm$ SD (range)	0.9 $\pm$ 0.4 (0.4-1.7)
Follow-up duration, mo, mean $\pm$ SD (range)	68.7 $\pm$ 37.7 (30-182)

BMI: Body mass index; F: Female; L: left; LFC: Lateral femoral condyle; M: Male; MFC: Medial femoral condyle; R: Right; SD: Standard deviation.

**Table 2 Clinical and radiological results of patients**

	Preoperative, mean $\pm$ SD (range)	At final follow-up, mean $\pm$ SD (range)	P value
Total KOOS score	29.4 $\pm$ 5.5 (21.4-40.5)	81.5 $\pm$ 5.9 (74.2-92.7)	< 0.01
Pain	32.2 $\pm$ 5.8	91.3 $\pm$ 4.2	< 0.01
Symptoms	28.2 $\pm$ 6.4	89.1 $\pm$ 7.2	< 0.01
ADL	44.5 $\pm$ 8.1	85.1 $\pm$ 6.8	< 0.01
Sport	22.4 $\pm$ 4.6	74.5 $\pm$ 7.2	< 0.01
QOL	24.5 $\pm$ 5.8	72.4 $\pm$ 8.1	< 0.01
MOCART score	NM	56.2 $\pm$ 10.7 (40-75)	NM
Kellgren-Lawrence grade	0.4 $\pm$ 0.1 (0-1)	0.6 $\pm$ 0.1 (0-1)	NS

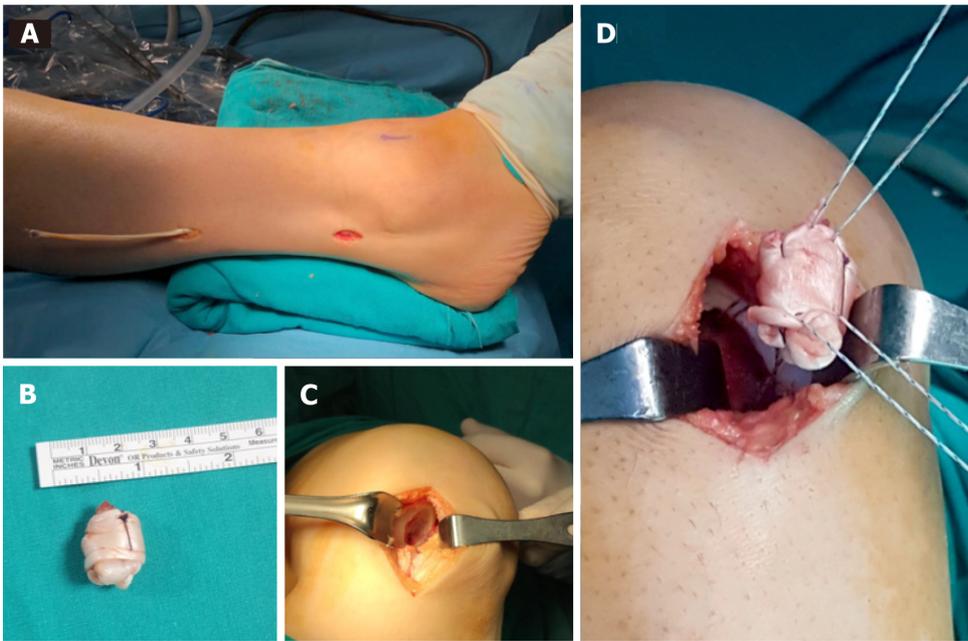
ADL: Activity of daily living; QOL: Quality of life; KOOS: Knee injury and osteoarthritis outcome score; MOCART: Magnetic resonance observation of cartilage repair tissue score; NM: Not measured; NS: Not significant; SD: Standard deviation.

reported a neurological symptom. Hypertrophic scar tissue did not occur in any of the patients in the donor site. At the end of the 6th month, all patients returned to their daily work and daily activities without any restrictions.

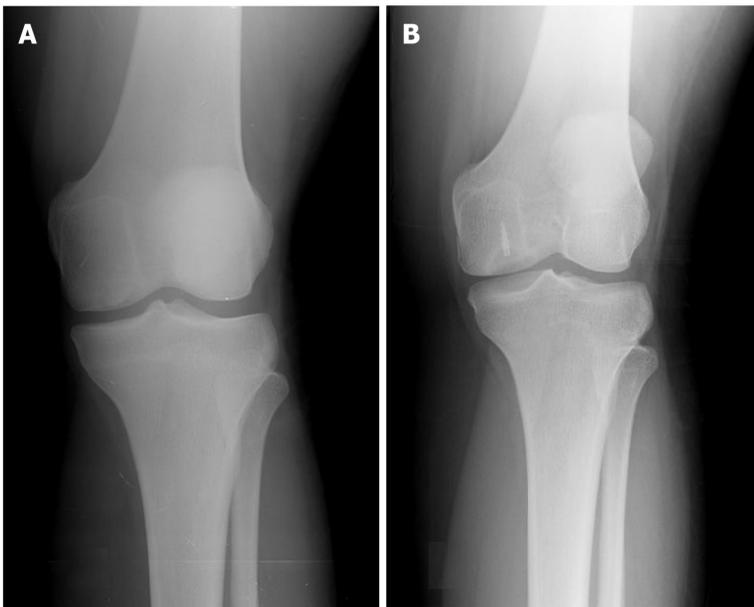
## DISCUSSION

The most important finding of the present study is that all of the patients treated with autologous tendon transplantation had "excellent and good" clinical and radiological outcomes with minimum 2 years follow-up. All parameters of the KOOS score improved significantly ( $P < 0.001$ ). Patients with less than 4 cm<sup>2</sup> lesion had statistically significantly better overall KOOS ( $P < 0.01$ ) than patients whose more than 4 cm<sup>2</sup> lesion.

The main aim in the treatment of osteochondral defect is to restore joint integrity by creating a tissue that is the same or similar to the biomechanical properties of the articular cartilage. This is the basic logic of this method. The reason we think of using tendons in the treatment of OCD is that the tendon has a viscoelastic and anisotropic structure that has main tasks of carrying energy from muscle to bone and storing energy with its highly organized hierarchy[13-15]. Tendons have been proven to increase their amounts of proteoglycan and glycosaminoglycan present in the matrix under compression conditions, and can resist compressive loads thanks to these two substances[13,15,16]. Another feature of the tendons is that they can change their structures and compositions in case of mechanical load changes. Cells in the tendon are responsible for adaptive changes and can alter gene expression, protein synthesis and cell phenotype against mechanical load. In addition, the extracellular matrix of the



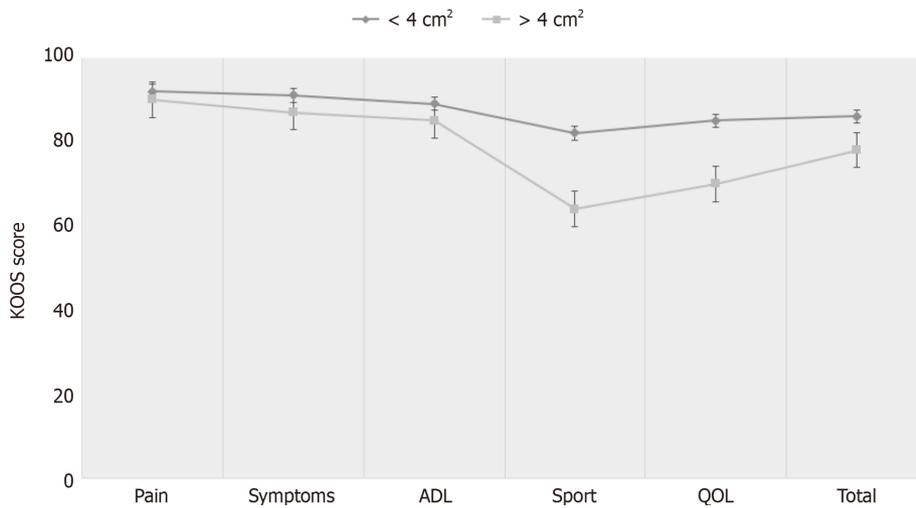
**Figure 1** The technique of harvesting the autologous peroneal tendon from the donor area and placing it in the prepared osteochondral lesion area of the knee. A: Two mini incisions were made in the ipsilateral leg to harvest a split portion of the peroneus longus tendon; B: Intraoperative image showing the rolled peroneus longus tendon with absorbable suture; C: Osteochondral defect was prepared for transplantation; D: The rolled tendon autograft was transplanted into the osteochondral defect space and fixed with suture anchor.



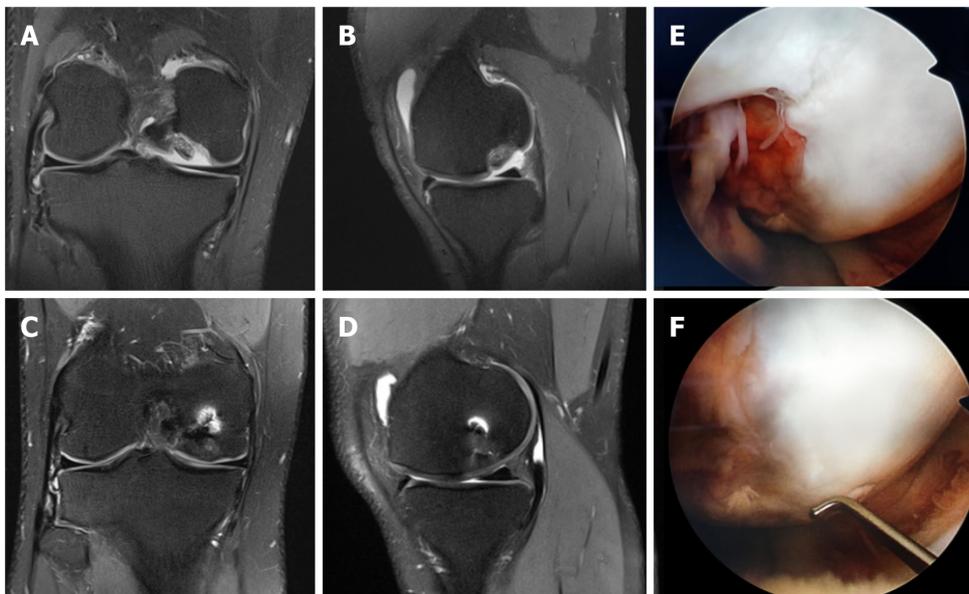
**Figure 2** Radiographic images of a patient treated with the Autologous Tendon Transplantation technique. A: Anteroposterior radiograph of the knee of a 24-year old female with a symptomatic lesion of the medial femoral condyle (4.6 cm<sup>2</sup> size and 1.4 cm depth); B: Anteroposterior radiograph of the knee 6 years after autologous tendon transplantation with suture anchor show congruency of the articular surface of the medial femoral condyle. There are no arthritic changes. The patient is asymptomatic, free from pain and has no limitation of movement.

tendon acts as a scaffold, allowing cell adhesion, development, and differentiation[16, 17]. Joint compliance is easily provided by the elastic structure of the tendon, hence solid structure forms a load carrying surface; thus, the pain is eliminated, joint functions are preserved and degeneration is stopped. The results of this technique we have described show that we have achieved this.

The technique we have described is actually a tissue-based cartilage repair technique. Therefore, it can be compared with osteochondral autograft or allograft repair techniques, which are tissue-based repair techniques. The most important advantage of the osteochondral autograft technique is that the graft is autograft and it



**Figure 3 Knee injury and osteoarthritis outcome scores for different defect size.** Patients with less than 4 cm<sup>2</sup> lesion had statistically significantly better overall knee injury and osteoarthritis outcome score than patients whose more than 4 cm<sup>2</sup> lesion, particularly in sport and quality of life subscales. KOOS: Knee injury and osteoarthritis outcome score; ADL: Activity of daily living; QOL: Quality of life.



**Figure 4 Magnetic resonance images and intraoperative images of a patient treated with the Autologous Tendon Transplantation technique.** A, B: Coronal and Sagittal T2 section magnetic resonance images (MRI) of a grade 4 osteochondral lesion involving articular surface of medial femoral condyle (3.4 cm<sup>2</sup> size and 0.5 cm depth) in 24-year old male; C, D: 1-year follow-up coronal and sagittal T2 section MRI showing complete filling of the defect and establishment of smooth articular surface; E, F: Second look arthroscopy view at 1-year follow-up of grade 4 osteochondral lesion of medial femoral condyle showing filling of the defect with a well-integrated, smooth surfaced and stable regenerated cartilage.

enables the subchondral tissue to be restored[18]. But it has potential disadvantages such as donor site morbidity and poor joint compliance. In addition, the larger the defect area is, the higher the risk of complications are[19]. The osteochondral autograft technique may exhibit mismatch in connection geometry at the recipient site. In addition, the need for multiple grafts in large lesions complicates the provision of joint geometry and increases donor site morbidity. This can cause premature degeneration of the graft and joint, synovitis, and pain[20-23].

Another tissue-based cartilage repair technique is osteochondral allografts. These allografts have been used for many years in orthopedic surgery to reconstruct osteochondral defects[24]. It has also become an option in the treatment of cartilage abnormalities affecting subchondral bones, such as osteochondritis dissecans[25]. Osteochondral allograft is a highly beneficial procedure especially in the treatment of large lesions that are between the sizes 2-20 cm<sup>2</sup> and in the treatment of a failed OCD [26-29]. Even if successful results have been reported in previous studies, the most

important disadvantage of osteochondral allografts are their shorter storage life. Williams *et al*[30] in their study; reported that fresh human osteochondral allograft tissue that was kept for more than fourteen days, preserves its glycosaminoglycan content and biomechanical properties, yet it significantly loses its chondrocyte viability, viable cell density and metabolic activity. Other disadvantages of this method are the difficulty of accessibility to the graft, immunogenicity and graft rejection, the risk of disease transmission such as HIV and Hepatitis, disjointedness in joint geometry and collapse problems[25,31]. With the autograft we used, the disadvantages of osteochondral allografts are avoided.

The most important limitation of this study is the small number of patients. Even if we compare the study with previous studies, the absence of a control group is another limitation. Cartilage evaluation was evaluated with standart (1.5 Tesla system (Avanto; Siemens Medical Solution, Erlangen, Germany) MRI. Another shortcoming is that we did not perform imaging with gadolinium-enriched MRI.

---

## CONCLUSION

---

This technique allows to avoid many of the disadvantages of other techniques. Important advantages; It is done in one step, it is an autograft, it does not require additional cost and it is easy to apply. Since it is an autograft, there is no risk of tissue rejection and contagious infection. Similar clinical and radiological results were obtained when compared to other treatment modalities. The autologous tendon transplantation is a single-step, safe, simple, cost-effective method for the treatment of knee OCD with satisfactory clinical and radiological outcomes, particularly in patients with less than 4 cm<sup>2</sup> lesion.

## ARTICLE HIGHLIGHTS

### **Research background**

This research was initiated by being inspired by the article titled "Treatment of osteochondral defects with tendon autografts in a dog knee model" made in 1999 and the articles titled "Tendon regeneration: an anatomical and histological study in sheep" published in 2004.

### **Research motivation**

Our teacher Ahmet Uğur Turhan's interest in joint surgery and his publications in 1999-2004 inspired him.

### **Research objectives**

In order to protect the knee joint, the authors share the new technique with the world, and share the results with the world and to inspire new publications.

### **Research methods**

A report of multiple patients with the same treatment, but no control group or comparison group.

### **Research results**

All parameters of the knee injury and osteoarthritis outcome score (KOOS) score improved significantly in all patients. Patients with lesions less than 4 cm<sup>2</sup> had a significantly better overall KOOS than patients with lesions greater than 4 cm<sup>2</sup>.

### **Research conclusions**

Autologous tendon transplantation has satisfactory clinical and radiological results in patients with osteochondral lesions of the knee.

### **Research perspectives**

The autologous tendon transplantation is a single-step, safe, simple, cost-effective method for the treatment of knee osteochondritis dissecans with satisfactory.

## REFERENCES

- 1 **Bruns J**, Werner M, Habermann C. Osteochondritis Dissecans: Etiology, Pathology, and Imaging with a Special Focus on the Knee Joint. *Cartilage* 2018; **9**: 346-362 [PMID: 28639852 DOI: 10.1177/1947603517715736]
- 2 **Andriolo L**, Candrian C, Papio T, Cavicchioli A, Perdisa F, Filardo G. Osteochondritis Dissecans of the Knee - Conservative Treatment Strategies: A Systematic Review. *Cartilage* 2019; **10**: 267-277 [PMID: 29468901 DOI: 10.1177/1947603518758435]
- 3 **Shea KG**, Jacobs JC Jr, Carey JL, Anderson AF, Oxford JT. Osteochondritis dissecans knee histology studies have variable findings and theories of etiology. *Clin Orthop Relat Res* 2013; **471**: 1127-1136 [PMID: 23054514 DOI: 10.1007/s11999-012-2619-6]
- 4 **Andriolo L**, Crawford DC, Reale D, Zaffagnini S, Candrian C, Cavicchioli A, Filardo G. Osteochondritis Dissecans of the Knee: Etiology and Pathogenetic Mechanisms. A Systematic Review. *Cartilage* 2020; **11**: 273-290 [PMID: 29998741 DOI: 10.1177/1947603518786557]
- 5 **Davies-Tuck ML**, Wluka AE, Wang Y, Teichtahl AJ, Jones G, Ding C, Cicuttini FM. The natural history of cartilage defects in people with knee osteoarthritis. *Osteoarthritis Cartilage* 2008; **16**: 337-342 [PMID: 17698376 DOI: 10.1016/j.joca.2007.07.005]
- 6 **Demirel M**, Polat G, Erşen A, Aşık M, Kılıçoğlu Ö. Internal fixation for osteochondritis dissecans lesions of the knee in patients with physeal closure. *Acta Orthop Traumatol Turc* 2021; **55**: 201-207 [PMID: 34100359 DOI: 10.5152/j.aott.2021.19307]
- 7 **Howell M**, Liao Q, Gee CW. Surgical Management of Osteochondral Defects of the Knee: An Educational Review. *Curr Rev Musculoskelet Med* 2021; **14**: 60-66 [PMID: 33587261 DOI: 10.1007/s12178-020-09685-1]
- 8 **Solheim E**, Hegna J, Øyen J, Harlem T, Strand T. Results at 10 to 14 years after osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee. *Knee* 2013; **20**: 287-290 [PMID: 23482060 DOI: 10.1016/j.knee.2013.01.001]
- 9 **Kowalczyk M**, Musahl V, Fu FH. Cochrane in CORR®: Surgical Interventions (Microfracture, Drilling, Mosaicplasty, and Allograft Transplantation) for Treating Isolated Cartilage Defects of the Knee in Adults. *Clin Orthop Relat Res* 2018; **476**: 16-18 [PMID: 29389754 DOI: 10.1007/s11999.00000000000000016]
- 10 **Turhan AU**, Aynaci O, Turgutalp H, Aydın H. Treatment of osteochondral defects with tendon autografts in a dog knee model. *Knee Surg Sports Traumatol Arthrosc* 1999; **7**: 64-68 [PMID: 10223525 DOI: 10.1007/s001670050123]
- 11 **Albano D**, Martinelli N, Bianchi A, Giacalone A, Sconfienza LM. Evaluation of reproducibility of the MOCART score in patients with osteochondral lesions of the talus repaired using the autologous matrix-induced chondrogenesis technique. *Radiol Med* 2017; **122**: 909-917 [PMID: 28770483 DOI: 10.1007/s11547-017-0794-y]
- 12 **Collins NJ**, Prinsen CA, Christensen R, Bartels EM, Terwee CB, Roos EM. Knee Injury and Osteoarthritis Outcome Score (KOOS): systematic review and meta-analysis of measurement properties. *Osteoarthritis Cartilage* 2016; **24**: 1317-1329 [PMID: 27012756 DOI: 10.1016/j.joca.2016.03.010]
- 13 **Böl M**, Ehret AE, Leichsenring K, Ernst M. Tissue-scale anisotropy and compressibility of tendon in semi-confined compression tests. *J Biomech* 2015; **48**: 1092-1098 [PMID: 25660384 DOI: 10.1016/j.jbiomech.2015.01.024]
- 14 **LaCroix AS**, Duenwald-Kuehl SE, Lakes RS, Vanderby R Jr. Relationship between tendon stiffness and failure: a metaanalysis. *J Appl Physiol (1985)* 2013; **115**: 43-51 [PMID: 23599401 DOI: 10.1152/jappphysiol.01449.2012]
- 15 **Zabrzynski J**, Gagat M, Paczesny Ł, Łapaj Ł, Grzanka D. Electron microscope study of the advanced tendinopathy process of the long head of the biceps brachii tendon treated arthroscopically. *Folia Morphol (Warsz)* 2018; **77**: 371-377 [PMID: 29131279 DOI: 10.5603/FM.a2017.0105]
- 16 **Wren TA**, Beaupré GS, Carter DR. Mechanobiology of tendon adaptation to compressive loading through fibrocartilaginous metaplasia. *J Rehabil Res Dev* 2000; **37**: 135-143 [PMID: 10850819 DOI: 10.1016/s0021-9290(97)00120-6]
- 17 **Wang JH**. Mechanobiology of tendon. *J Biomech* 2006; **39**: 1563-1582 [PMID: 16000201 DOI: 10.1016/j.jbiomech.2005.05.011]
- 18 **Schrock JB**, Kraeutler MJ, Houck DA, McQueen MB, McCarty EC. A Cost-Effectiveness Analysis of Surgical Treatment Modalities for Chondral Lesions of the Knee: Microfracture, Osteochondral Autograft Transplantation, and Autologous Chondrocyte Implantation. *Orthop J Sports Med* 2017; **5**: 2325967117704634 [PMID: 28516106 DOI: 10.1177/2325967117704634]
- 19 **Gowd AK**, Cvetanovich GL, Liu JN, Christian DR, Cabarcas BC, Redondo ML, Verma NN, Yanke AB, Cole BJ. Management of Chondral Lesions of the Knee: Analysis of Trends and Short-Term Complications Using the National Surgical Quality Improvement Program Database. *Arthroscopy* 2019; **35**: 138-146 [PMID: 30473458 DOI: 10.1016/j.arthro.2018.07.049]
- 20 **Miniaci A**, Tytherleigh-Strong G. Fixation of unstable osteochondritis dissecans lesions of the knee using arthroscopic autogenous osteochondral grafting (mosaicplasty). *Arthroscopy* 2007; **23**: 845-851 [PMID: 17681206 DOI: 10.1016/j.arthro.2007.02.017]
- 21 **Sgaglione NA**, Miniaci A, Gillogly SD, Carter TR. Update on advanced surgical techniques in the treatment of traumatic focal articular cartilage lesions in the knee. *Arthroscopy* 2002; **18**: 9-32 [PMID: 11828343 DOI: 10.1053/jars.2002.31783]

- 22 **Yoshizumi Y**, Sugita T, Kawamata T, Ohnuma M, Maeda S. Cylindrical osteochondral graft for osteochondritis dissecans of the knee: a report of three cases. *Am J Sports Med* 2002; **30**: 441-445 [PMID: 12016089 DOI: 10.1177/03635465020300032301]
- 23 **Wang CJ**. Treatment of focal articular cartilage lesions of the knee with autogenous osteochondral grafts. A 2- to 4-year follow-up study. *Arch Orthop Trauma Surg* 2002; **122**: 169-172 [PMID: 11928001 DOI: 10.1007/s004020100343]
- 24 **Filardo G**, Andriolo L, Soler F, Berruto M, Ferrua P, Verdonk P, Rongieras F, Crawford DC. Treatment of unstable knee osteochondritis dissecans in the young adult: results and limitations of surgical strategies-The advantages of allografts to address an osteochondral challenge. *Knee Surg Sports Traumatol Arthrosc* 2019; **27**: 1726-1738 [PMID: 30523367 DOI: 10.1007/s00167-018-5316-5]
- 25 **Gomoll AH**, Madry H, Knutsen G, van Dijk N, Seil R, Brittberg M, Kon E. The subchondral bone in articular cartilage repair: current problems in the surgical management. *Knee Surg Sports Traumatol Arthrosc* 2010; **18**: 434-447 [PMID: 20130833 DOI: 10.1007/s00167-010-1072-x]
- 26 **Emmerson BC**, Görtz S, Jamali AA, Chung C, Amiel D, Bugbee WD. Fresh osteochondral allografting in the treatment of osteochondritis dissecans of the femoral condyle. *Am J Sports Med* 2007; **35**: 907-914 [PMID: 17369560 DOI: 10.1177/0363546507299932]
- 27 **Levy YD**, Görtz S, Pulido PA, McCauley JC, Bugbee WD. Do fresh osteochondral allografts successfully treat femoral condyle lesions? *Clin Orthop Relat Res* 2013; **471**: 231-237 [PMID: 22961315 DOI: 10.1007/s11999-012-2556-4]
- 28 **Lyon R**, Nissen C, Liu XC, Curtin B. Can fresh osteochondral allografts restore function in juveniles with osteochondritis dissecans of the knee? *Clin Orthop Relat Res* 2013; **471**: 1166-1173 [PMID: 22972653 DOI: 10.1007/s11999-012-2523-0]
- 29 **McCulloch PC**, Kang RW, Sobhy MH, Hayden JK, Cole BJ. Prospective evaluation of prolonged fresh osteochondral allograft transplantation of the femoral condyle: minimum 2-year follow-up. *Am J Sports Med* 2007; **35**: 411-420 [PMID: 17261573 DOI: 10.1177/0363546506295178]
- 30 **Williams SK**, Amiel D, Ball ST, Allen RT, Wong VW, Chen AC, Sah RL, Bugbee WD. Prolonged storage effects on the articular cartilage of fresh human osteochondral allografts. *J Bone Joint Surg Am* 2003; **85**: 2111-2120 [PMID: 14630839 DOI: 10.2106/00004623-200311000-00008]
- 31 **Enneking WF**, Campanacci DA. Retrieved human allografts: a clinicopathological study. *J Bone Joint Surg Am* 2001; **83**: 971-986 [PMID: 11451965]



Published by **Baishideng Publishing Group Inc**  
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA  
**Telephone:** +1-925-3991568  
**E-mail:** [bpgoffice@wjgnet.com](mailto:bpgoffice@wjgnet.com)  
**Help Desk:** <https://www.f6publishing.com/helpdesk>  
<https://www.wjgnet.com>

