Original Research

Medial femoral condyle width and osteochondritis dissecans: Cause or effect and the implications for osteochondral allograft transplantation

Mitchell S. Mologne a,*, CAPT Matthew T. Provencher a,b, and Timothy S. Mologne c

a Steadman Philippon Research Institute, Vail, CO, USA
b The Steadman Clinic, Vail, CO, USA
c Orthopedic and Sports Institute of the Fox Valley, Appleton, WI, USA

A R T I C L E   I N F O
Keywords:
Osteochondritis dissecans
Osteochondral allograft transplantation
Medial femoral condyle

A B S T R A C T

Introduction: Anecdotally, patients with osteochondritis dissecans (OCD) have larger medial femoral condyles widths (MFCW), making it difficult finding size-matched condyles for osteochondral allograft transplantation.

Objectives: (1) measure MFCW and tibial plateau width (TPW) using magnetic resonance imaging (MRI) in patients with OCD of the MFC and (2) compare MFCWs and MFCW/TPW of patients with OCD to age and sex-matched controls.

Methods: We identified 111 patients with OCD of the MFC that had MRIs available for review. 115 age-matched patients that had MRIs for conditions that did not include medial compartment pathology served as controls. MFCW and TPW were measured on MRIs; MFCW/TPW ratio was calculated. Patients were assigned to 4 groups based on age. A student t test statistic was used to compare MFCW and MFCW/TPW between the 4 groups as well as to the age and sex matched controls.

Results: The 111 OCD patients (70 males, mean age: 25.7) had a mean MFCW of 29.3 mm. The 115 control patients (74 men, mean age: 25.6) had a mean MFCW of 24.8 mm. Men with OCD had wider MFCs compared to women (P < .001). For both the OCD and control populations, there was no statistical difference between MFCW and age. Overall, when controlling for age and sex, OCD patients had larger MFCWs than controls (P < .001).

Conclusions: Uniform widening of the MFC in OCD patients lends evidence that a wider MFC might be causal in the development of OCD.

Introduction

Osteochondritis dissecans (OCD) of the knee is a relatively rare cause of knee dysfunction and pain that has been recognized for over 100 years. There are many theories on the pathogenesis of OCD, including biologic and genetic factors, anatomic factors, and repetitive micro-traumatic causes.1-4 The most common location for OCD in the knee is the lateral aspect of the medial femoral condyle (MFC). When lesions continue to be symptomatic despite conservative management, surgical options become reasonable, including osteochondral allograft transplantation.5 While use of non-orthotopic lateral femoral condyle grafts are excellent graft options for MFC lesions,6 including OCD lesions,7 most surgeons request size-matched MFC grafts for MFC lesions. The width and size of the MFC

* Mitchell Scott Mologne, Steadman Philippon Research Institute, 181 W Meadow Dr STE 1000, Vail, CO 81657.

Email address: mmologne@gmail.com (M.S. Mologne).

https://doi.org/10.1016/j.jcjp.2022.100078
Received 14 June 2022; Revised 17 August 2022; Accepted 22 August 2022
Available online xxx
2667-2545/© 2022 The Author(s). Published by Elsevier B.V. on behalf of International Cartilage Regeneration and Joint Preservation Society. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/)
has been studied previously and there are gender and race variations. More so, women generally have smaller femoral condyles as compared to men. Analysis of 5962 donors of distal femoral allografts revealed that the mean medial femoral condyle width (MFCW) in women donors was 23.9 mm, while in men it was 26.1 mm. Overall, the mean MFCWs was 25.6 mm in 5962 donors younger than 35 years of age (Data on file, Joint Restoration Foundation).

The size of the MFC has been linked to medial compartment pathology. Specific MFC morphologic characteristics have not, however, been linked to OCD. While stress changes as a result of an OCD lesion can occur, the question is whether a wider MFC is an anatomic factor that can lead to an OCD lesion.

It has been our experience that the MFC in patients with OCD is larger than normal. In many situations, the width of the patient’s condyle exceeds the width of any donor condyle. In those situations, surgeons desiring a sized-match orthotopic condyle may never be offered a suitable graft because of the rarity of large MFC donor grafts.

The purposes of this study were to measure MFCWs and tibial plateau width (TPW) using magnetic resonance imaging (MRI) in patients with OCD of the MFC and compare MFCWs and MFCW/TPW ratios of patients with OCD to an age and sex-matched, healthy control group.

Materials and methods

We conducted a case control study of patients with OCD of the MFC. From a computer database of patients, we identified 126 patients that were diagnosed with OCD of the MFC from the years 2006 to 2019. Inclusion criteria were patients with isolated OCD of the MFC who had an MRI that was available for review. Exclusion criteria included those who were diagnosed with concomitant pathology in addition to OCD of the MFC, OCD in areas of the knee other than the lateral aspect of the MFC, obvious medial compartment osteoarthritis with marginal osteophytes, and articular cartilage loss on the non-OCD portions of the MFC. Following a review of the MRIs, we excluded 15 patients, giving us 111 OCD patients that were the subject of the study. Aged matched controls that had MRIs of their knees for conditions other than medial compartment pathology were also included in the study. Inclusion criteria for the control group were those with MRIs of their knees for acute isolated ACL tears, patellar instability, and isolated lateral meniscus tears. Any control patients that were noted to have any medial compartment pathology, including medial meniscus tears, chondral lesions in the medial compartment, and medial collateral ligament injuries, were excluded from the control group. 115 patients served as the control group.

We conducted a power analysis to help determine sample size for our study. We used a mean MFC width of 25.6 mm ± 2.50 mm, which was calculated from 5962 donors younger than 35 years of age (Data on file, Joint Restoration Foundation). We defined a clinically significant increase in MFC width to be 4 mm. We chose 4 mm as clinically significant because of donor MFC availability, as donor MFC grafts are rarely available at or greater than 29.0 mm. Based on a 4.0 mm increased MFC width, power of 0.8, and an alpha of 0.05, it was determined that a minimum sample size of 12 would be needed to show significance.

Each OCD and control patient had an MRI performed on a 1.5 Tesla scanner. We analyzed Proton Density Fast Spin Echo and T1 FSE coronal sequences on each patient and control. We selected a coronal MRI image that was in the mid-point of the MFC and which best outlined the medial and lateral bone of the MFC. The image was referenced from anterior to posterior, and the PACS DICOM (Med-Dream Web Dicom Viewer Aycan Medical Systems) sequence correlation tool was used on corresponding MRI sagittal sequences to define the appropriate coronal image for measurement. The MFCW and (TPW were measured using the PACS DICOM software for the study patients and controls (image 1). Measurements using the PACS system was accurate to 0.01 mm. MFCW/TPW ratio was also calculated.

Patients were grouped by decade with 10 to 20 years in Group 1, 21 to 30 years in Group 2, 31 to 40 years in Group 3, and 41 years and older in Group 4. Each group was further separated by gender (F = female; M = male).

A student t test statistic was used to compare MFCW and the quotient of MFCW/TPW between the 4 groups as well as to the age and sex matched controls. A post-hoc analysis was performed between each of the OCD and control groups in each of the age-gender groups to further assess the power of statistically significant results.

Results

The 111 patients with osteochondritis of the MFC included 70 males and 41 females with a mean age of 25.7 years. The 115 control patients included 74 males and 41 female patients with a mean age of 25.6 years. In the OCD group, the overall mean MFC width was 29.3 mm. When the OCD patients were grouped by age, Group 1 (ages 10-20 years) had a mean MFC width of 28.9 mm; Group 2 (ages 21-30 years) had a mean width of 29.2 mm; Group 3 (ages 31-40 years) had a mean width of 29.5 mm. There was no statistical difference in MFC width in the OCD patients with respect to age. Men patients with OCD had a mean MFC of 30.4 mm compared to women OCD patients with a mean width of 27.2 mm. Using a student t test statistic, this difference was statistically significant with P < .001 (Table 1).

The control patients had an overall mean MFC width of 24.8 mm, with men having a mean MFC width of 26.5 mm and women having a mean MFC width of 23.6 mm. There was no difference in MFC width in the control group with respect to age, but like the OCD patients, men in the control group had a wider MFC as compared to women (P < .001). Overall, the MFC width in OCD patients was statistically greater than the controls with a P < .001. This observation was present when controlling for age and sex (Table 1, Fig. 2).
The width of the MFC and MFCW/TPW ratio in patients with OCD of the MFC is statistically greater than controls, even when controlling for age and gender. Men were found to have wider MFCW compared to women in both the OCD patients and controls. Widening of the MFC was even seen in Group 1 patients and in patients as young as 10 years of age. It is unknown whether a wider MFC is a risk factor for developing an OCD lesion of the MFC. The widening of the MFC was uniform, as compared to widening that is seen with a marginal osteophyte as a result of meniscus deficiency and articular cartilage pathology. Our results support the concept that widening of the MFC is a cause of OCD and not the result of OCD. However, further studies are needed to explore this concept.
Fig. 1. Availability of lateral and medial femoral condyle donor grafts taken on file from Joint Restoration Foundation (Centennial, CO). There is a relative paucity of large medial femoral condyles which may lead to surgeons opting to choose lateral femoral condyles for osteochondral allograft transplantation for large chondral defects of the medial femoral condyle.

Fig. 2. A-D Medial femoral condyle widths between the sexes for OCD and control populations in each of the 4 age-groups. OCD patients had wider MFCs when comparing OCD and control for both sexes in each of the 4 age-groups.

Our study does have strengths, including the fact that it is the largest study to date in literature of patients with OCD of the MFC. This study also is the first to report the increased size of the MFC in OCD patients compared to control as well as to data available for normal femoral condyle metrics.

The results of this study are clinically relevant to joint restoration surgeons that use osteochondral allograft transplantation in the treatment of OCD of the MFC. Requests for a size-matched orthotopic MFC graft is the accepted standard that most surgeons use. However, finding a size-matched allograft for patients with OCD of the MFC will be challenging, given the sizes of MFC grafts that are typically available for transplant. Analysis of 5962 donors of distal femoral allografts revealed that the mean MFCW in women donors was 23.9 mm, while in men it was 26.1 mm. Overall, the mean MFC width was 25.6 mm ± 2.5 mm (Data on file at Joint Restoration Foundation, Centennial, CO) (Fig. 1). In our analysis, the mean MFC width in patients with OCD was 29.3 mm. Donor
MFC allografts are rarely available at or greater than 29.0 mm. Using an undersized MFC graft, particularly if the graft is 4 mm narrower than the patient, can be difficult to achieve an anatomic restoration of the articular surface due to the different surface topography and radius of curvature. If a surgeon desires a size-matched condyle graft, consideration for using a non-orthotic lateral femoral condyle allograft would lead to more available donors. Approximately 75% of condyles that are wider than 26 mm are lateral femoral condyles (data on file, Joint Restoration Foundation) (Fig. 1). Large lateral femoral condyle are readily available and should be considered as suitable graft options for osteochondral allograft transplant in patients with an OCD of the MFC.

There are limitations to this study. The study was conducted on MRIs of patients that we identified as having a diagnosis of OCD of the MFC. We acknowledge that there are certainly patients that are diagnosed with an OCD that are much younger than our study patients. Our youngest patient in our OCD group was 10 years of age, yet we did not have many patients that were skeletally immature and truly in the earliest ages of onset of OCD. As such, we are not able to definitively conclude that a larger MFC is a risk factor for development of OCD. However, our patients did not have the typical adaptive bony changes seen in patients with meniscal deficiency and osteoarthritis, including condyle flattening and marginal osteophytes. Additional studies in skeletally immature pediatric patients with OCD of the MFC may help to answer the question as to whether a wider MFC is a cause or effect.

Group 4 Male had very few patients, which was a potential explanation for the post-hoc analysis result in that group. However, we do not feel this small subset changes the overall power and overall conclusions.

We used PACS software to measure the MRI (Med- Dream Web Dicom Viewer, Aycan Medical Systems). The measurement tool for this PACS system is accurate to 0.01 mm. However, while our measuring protocol was not validated, we still feel our ability to accurately measure condyle and plateau widths was accurate. The software had accuracy to 0.01 mm but we chose to round to the nearest tenth of a millimeter.

Conclusion

The MFC is statistically wider in patients with OCD of the MFC compared to normal age and sex matched controls. The uniform widening as opposed to widening from a marginal osteophyte and the presence of widening even in patients as young as 10 years of age supports the concept that the widening of the condyle is a cause more than an effect of OCD. Surgeons performing osteochondral allograft transplantation for symptomatic OCD lesions of the MFC may need to consider a non-orthotic lateral femoral condyle donor graft if size matching is important, as there is a paucity of large MFC donor grafts that would match the sizes seen in patients with OCD of the MFC.

Disclosures

MSM reports no disclosures. MTP discloses: royalties received from Arthrex, Inc.; paid consultant for Joint Restoration Foundation (JRF), SLACK Inc., Elsevier Inc.; Editorial or Governing Board of Arthroscopy, Knee, Orthopaedics, SLACK; Board of Directors member for AANA, AOSSM, ASES, ISAKOS, Military Orthopedic Surgeons. TSM discloses: Paid speaker and consultant for Joint Restoration Foundation; Advisory consultant for Samumed; Research support from Arthrex and Joint Restoration Foundation. Exempt IRB approval was obtained through the Vail Health Institutional Review Board. IRB Number: 2021-061.

Informed patient consent

Complete written informed consent was obtained from the patient for the publication of this study and accompanying images.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Timothy Mologne reports a relationship with JRF Ortho that includes: consulting or advisory and speaking and lecture fees. Matthew Provencher reports a relationship with JRF Ortho that includes: consulting or advisory.

References

1. Nambu T, Gasser B, Schneider E, Bandi W, Perren SM. Deformation of the distal femur: a contribution towards the pathogenesis of osteochondrosis dissecans in the knee joint. J Biomech. 1991;24(6):421–433 Elsevier.
2. Stone AV, Little KJ, Glov DL, Stringer KF, Wall EJ. Repetitive stresses generate osteochondral lesions in skeletally immature rabbits. Am J Sports Med. 2016;44(11):2957–2966 SAGE Publishing.
3. Chow RM, Guzman MS, Dao Q. Intercondylar Notch Width as a Risk Factor for Medial Femoral Condyle Osteochondritis Dissecans in Skeletally Immature Patients. J Pediatr Orthop. 2016;36(6):640–644 Wolters Kluwer N.V.
4. Cavaignac E, Ferroncelli G, Thépaut M, Vial J, Accadbled F, Gauzy JSD. Relationship between tibial spine size and the occurrence of osteochondritis dissecans: an argument in favour of the impingement theory. Knee Surg Sports Traumatol Arthrosc. 2015;23(8):2442–2446 Springer Nature.
5. Emmerson BC, Göritz S, Jamali AA, Chung C, Amiel D, Bugbe WD. Fresh osteochondral allografting in the treatment of osteochondritis dissecans of the femoral condyle. Am J Sports Med. 2007;35(6):907–914 SAGE Publishing.
6. Mologne TS, Cory E, Hansen B, et al. Osteochondral allograft transplant to the medial femoral condyle using a medial or lateral femoral condyle allograft: is there a difference in graft sources? Am J Sports Med. 2014;42(9):2205–2213 SAGE Publishing.
7. Salka N, Grant JA. Contra lateral Lateral Femoral Condyle Allografts Provide an Acceptable Surface Match for Simulated Classic Osteochondritis Dissecans Lesions of the Medial Femoral Condyle. Orthop J Sports Med. 2018;6(7_suppl4):1–9 SAGE Publishing.
8. Li P, Tsi T, Li JS, et al. Gender analysis of the anterior femoral condyle geometry of the knee. Kneec. 2013;21(2):529–533 Elsevier.
9. Park JS, Nam DC, Kim DH, Kim HK, Hwang SC. Measurement of Knee Morphometrics Using MRI: a Comparative Study between ACL-Injured and Non-Injured Knees. Knee Surg Relat Res. 2012;24(3):180–185 Springer Nature.
10. Otterness IG, Eckstein F. Women have thinner cartilage and smaller joint surfaces than men after adjustment for body height and weight. Osteoarthritis Cartilage. 2007;15(6):666–672 Elsevier.
11. Indrawati R, Lukitasari D, Yuniati Y, et al. Encapsulation, Properties, and Thermal Study of Red Biocolorant from Selected Plants Obtained Through Physical Extraction. Int J Chem Eng Appl. 2017;8(6):371–376 EJournal Publishing.
12. Chung JY, Song H, Jung M, et al. Larger medial femoral to tibial condylar dimension may trigger posterior root tear of medial meniscus. Knee Surg Sports Traumatol Arthrosc. 2015;24(5):1448–1454 Springer Nature.
13. Grammens J, Haver AV, Danckaers F, Booth B, Sijbers J, Verdonk P. Small medial femoral condyle morphotype is associated with medial compartment degeneration and distinct morphological characteristics: a comparative pilot study. Knee Surg Sports Traumatol Arthrosc. 2020;29(6):1777–1789 Springer Nature.
14. Wada M, Tatsu H, Baha H, Asamoto K, Nojio Y. Femoral intercondylar notch measurements in osteoarthritic knees. Rheumatology (Oxford). 1999;38(6):554–558 Mercury International.
15. Coyner K, Ensminger S, Matuszak S, et al. Contact Pressure Properties of Osteochondral Defects of the Knee: the Effect of Non-Vertical Walls (SS-57. Arthrosc J Arthrosc Relat Surg. 2009;25(6):e31–e32 Elsevier.
16. Guettler JH, Demetroppoulos CK, Yang KH, Jurist KA. Osteochondral defects in the human knee: influence of defect size on cartilage rim stress and load redistribution to surrounding cartilage. Am J Sports Med. 2004;32(6):1451–1458 SAGE Publishing.
17. Zhong Q, Pedola V, Tanaka M, Ma B, Li X. Bone Shape Changes From Baseline to 6-Month Are Associated With Cartilage T1ρ & T2 and Knee Injury&Osteoarthritis Outcome Score at 3-Year After Anterior Cruciate Ligament Reconstruction. Osteoarthritis Cartilage. 2017;25:S241–S242 Elsevier.
18. FAIRBANK TJ. Knee joint changes after meniscectomy. Bone Joint J. 1948;30B(4):664–670 British Editorial Society of Bone & Joint Surgery.