Original Research

Preoperative symptom duration does not affect clinical outcomes after high tibial osteotomy at a minimum of 2-year follow-up

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ABSTRACT

Objectives: To determine if patients with preoperative symptom durations greater than two-years’ experience inferior patient-reported and clinical outcomes at a minimum of two years after high tibial osteotomy.

Methods: An institutional registry was retrospectively queried for patients treated with high tibial osteotomy for symptomatic medial knee overload/arthritis and varus malalignment between February 2006 and March 2018. Demographic characteristics, clinical outcomes, patient-reported outcomes (PROs), including the International Knee Documentation Committee score, Knee Injury and Osteoarthritis Outcome Score for Joint Replacement and Patient-Reported Outcome Measurement Information System Pain Interference and Physical Function scores, were assessed at a minimum of two-years postoperatively. Patients were compared based on preoperative symptom duration greater than or less than two years. Correlation coefficients were used to analyse the association between patient demographics and postoperative outcomes for the overall patient sample.

Results: A total of 41 patients were included in the analysis with a mean age (± standard deviation) of 37.0 ± 8.2 years and body mass index of 27.6 ± 4.2 kg/m². The median (interquartile range) follow-up time for the entire study sample was 48.5 (24–100.5) months. There were no significant differences in delta (pre-to-post improvement) or postoperative PRO scores, number or time-to-reoperation or conversion to TKA (all P > 0.05) based on the preoperative duration of symptoms. A statistically significant but weak correlation was observed between greater age (r = 0.344, P = 0.027) and BMI (r = 0.320, P = 0.044) with conversion to TKA.

Conclusion: Patients with a preoperative duration of symptomatic medial knee overload/arthritis of two years or greater do not experience inferior PRO or clinical outcomes than patients with a symptom duration of less than 2 years at mid-term follow-up. Greater age and BMI were weakly correlated with conversion to TKA. Greater age was negatively correlated with undergoing at least one reoperation.

Level of evidence: IV; Retrospective case series.

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What are the new findings?

- Patients with preoperative symptom duration greater than two years demonstrated no significant differences in reoperations, time-to-reoperation or conversion to total knee arthroplasty relative to patients with symptom duration less than two years.
- Statistically significant correlations were noted between greater age and BMI with conversion to total knee arthroplasty.

Introduction

High tibial osteotomy (HTO) is a universally accepted procedure used to treat varus malalignment and medial compartment overload/osteoarthritis (OA) by shifting the mechanical axis to unload the medial compartment [1,2]. Medial compartment overload/OA is more commonly observed than lateral because the medial side of the knee bears a greater proportion of the load in a normal weight-bearing gait. The reduction in medial loading after HTO results in significant pain reduction, improved physical function, long-term survival in affected arthritic patients and prevention or delay of future knee arthroplasty [2].

The impact of various factors on outcomes following HTO has been evaluated previously in the literature, including obesity [3], ligamentous stability [1,4], deficits in range of motion [5], age [6] and correction parameters including over-correction, under-correction and loss of correction [7,8]. In contrast, there is a paucity of literature investigating the association between preoperative symptom duration and outcomes after HTO. The impact of this clinical consideration on postoperative outcomes has been assessed for other orthopaedic pathologies, such as femoral acetabular impingement syndrome [9], cervical spondylotic radiculopathy [10] and lumbar spinal stenosis [11], with varied results. The determination of whether such a relationship exists between the duration of symptomatic medial knee overload/OA prior to HTO is important for clinicians because this knowledge could impact patient counselling and the timing of surgery.

The purpose of the current study was to determine the effect of the preoperative symptom duration on patient-reported and objective clinical outcomes at a minimum of two years after HTO. The authors hypothesized that patients with symptom durations greater than two years would experience inferior patient-reported outcome (PRO) scores and higher rates of reoperations and conversion to total knee arthroplasty (TKA) than patients with symptom duration less than two years at a minimum of two-year follow-up after HTO.

Methods

Patient selection

The present study received institutional review board approval prior to initiation. All patients were treated by one of six board-certified and fellowship-trained orthopaedic surgeons at a large, tertiary centre. Each surgery was performed by only one of the six orthopaedic surgeons. All patients undergoing HTO for symptomatic medial knee overload/OA and varus malalignment between February 1, 2006 and March 1, 2018 were retrospectively evaluated for potential inclusion in this study. All patients were diagnosed with symptomatic medial knee overload/OA with varus malalignment and failed a course of conservative management prior to surgical intervention. To be eligible for inclusion, patients must have had radiographs taken prior to surgery (anteroposterior (AP), 45° posteroanterior (PA) Rosenberg view and full-lower limb mechanical axis films) and fully completed at least one postoperative PRO questionnaire at a minimum of two years postoperatively. Patients undergoing HTO with concomitant cartilage restoration or ligamentous procedures were not excluded. Patients meeting inclusion criteria were then dichotomously stratified based on the duration of symptomatic medial knee overload/OA greater than or less than two years prior to surgery. A symptom duration of two years was chosen based on prior orthopaedic sports medicine literature [9]. A posteriori sensitivity analysis was performed to investigate symptoms of duration cut-offs of 18- and 36-months. The onset of knee-related symptoms was self-reported by patients during the initial clinical presentation and recorded in an electronic outcomes database (Outcome Based Electronic Research Database; Universal Research Solutions, Columbia, MO, USA). In cases where patients underwent treatment prior to the use of Outcome Based Electronic Research Database by our institution, the onset of symptoms was extracted from provider clinical notes or by directly contacting the patient.

Surgical technique

All procedures were performed in a similar manner across providers. The operative knee was prepped and draped in a typical sterile fashion and two portal diagnostic arthroscopies were performed. Procedures addressing concurrent intraarticular pathology of the chondral surfaces, menisci and ligaments were performed first followed by the HTO. In brief, the incision was made approximately 2–3 cm posterior to the tibial tubercle, just distal to the joint line. The incision was carried down to the sartorius, opening the fascia. The medical collateral ligament (MCL) and pes anserine tendons were identified. The MCL was reflected and elevated in a subperiosteal fashion. The osteotomy was then performed under fluoroscopic guidance, using a combination of guide pins, oscillating saw and osteotome to ensure a sufficient hinge at the opposite lateral cortex. Wedge dilators were used to the preoperative planned correction and the appropriate size plate was placed and the void was filled with bone graft (allograft source).

Radiographic measurements

Radiographic measurements of preoperative images were performed to quantify the varus malalignment and presence of osteoarthritis preoperatively. Alignment was assessed using full limb standing mechanical axis films. The centre of the femoral head was first identified using a perfect circle drawn using a picture archiving and communications system (PACS) (Opal-RAD PACS, Viztek). A line was then drawn from the centre of the femoral head through the centre of the distal tibial plafond. The varus alignment was quantified based on the point where the mechanical axis line crossed the tibial plateau (relative to the medial border) as a percentage of the entire plateau width. Osteoarthritis was quantified based on joint space width measurements made at 3 different points on the medial plateau. The width of the medial plateau was measured from the medial border of the plateau to the centre of the medial tibial spine. The perpendicular joint space was measured at 25%, 50%, and 75% of this measured distance. All measurements were made by two independent reviewers with varying levels of medical training (medical student and orthopaedic surgery resident) and under the guidance of one of the senior authors (E.M.P. and B.T.W. supervised by J.C.). Both reviewers performed measurements for all 41 patients, which were used to calculate inter-observer reliability. All 41 measurements were then repeated by the primary reviewer (E.M.P.) for the purpose of assessing intraobserver reproducibility. The measurements from the primary reviewer were used for reporting final measurements and correlations.

Patient-reported and clinical outcomes

Patients completed knee-specific outcome questionnaires preoperatively and at a minimum of two years postoperatively. Knee questionnaires included the International Knee Documentation Committee (IKDC) score and the Knee Injury and Osteoarthritis Outcome Score for Joint Replacement (KOOS JR) [12]. In addition, patient-centred outcome
measures, including the Patient-Reported Outcome Measurement Information System Pain Interference (PROMIS-PF) and Physical Function (PROMIS-PF) questionnaires [13], were administered at the final follow-up. The PROMIS questionnaires were only administered at the final follow-up because they were not implemented at our institution until 2017. Patients who had less than 2-year follow-up data at the time of retrospective review were contacted for collection of the IKDC, KOOS JR, PROMIS-PF and PROMIS-PF scores.

## Statistical analysis

Assumptions for parametric testing of data were evaluated prior to analysis and appropriate parametric or non-parametric tests for the comparison of variables at baseline were used. Patients were deemed lost to follow-up if they could not be reached after 5 attempts at contact or due to missing or obsolete contact information. Continuous variables were presented as either means with standard deviations or medians and interquartile ranges, for normally and non-normally distributed data, respectively, according to Shapiro-Wilk tests. Categorical variables were reported as frequencies with relative percentages. Complete case analysis was used to accommodate instances of missing data. Reliability between raters was assessed using intraclass correlation coefficients (ICC) for each radiographic measurement [14]. For the assessment of intra-rater ICCs, measurements were repeated by the primary rater at a minimum interval of 2 weeks to minimize recall bias. For interpretation, ICC values between 0.5 and 0.75 indicated moderate reliability, 0.75 and 0.9 indicated good reliability, whereas values greater than 0.9 indicated excellent reliability [14]. Paired t-tests were used to determine if mean PRO scores significantly differed at final follow-up relative to baseline values. Postoperative clinical outcomes (i.e. reoperations and conversion to TKA) between patients with greater than and less than two years of symptom duration were assessed using chi-squared tests or Fisher’s exact test when cell counts were otherwise noted.

## Results

Of the 125 eligible patients, 18 were not administered postoperative PROs and were considered lost to follow-up due to obsolete contact information. Of the remaining 107 that were administered postoperative PROs, 41 met final inclusion criteria and were included in the analysis. A total of 66 patients were excluded due to inadequate completion of preoperative imaging (n = 32) or postoperative patient-reported outcomes (n = 34). The study cohort had a mean age (± standard deviation) of 37.0 ± 8.2 years and a body mass index of 27.6 ± 4.2. Of the 41 patients, 12 (29.3%) were female (Table 1). The median follow-up time (interquartile range) was 48.5 (24–100.5) months and the degree of correction intraoperatively was 9.0 (7.5–10.0) degrees. All of the patients included in the study underwent a HTO procedure for medial compartment unloading and varus malalignment. Pertinent concomitant procedures are listed in Table 1. The overall inter-rater reliability ICC (95% confidence interval) for medial joint space width (JSW) measurements on AP and PA radiographs were 0.716 (0.486–0.832) and 0.719 (0.352–0.860), respectively. The inter-rater ICC for varus malalignment on mechanical axis radiographs was 0.991 (0.983–0.995). Overall intra-rater ICCs for the primary rater were 0.911 (0.874–0.938) for JSW on AP, 0.896 (0.844–0.931) for JSW on PA, and 0.995 (0.991–0.997) for varus malalignment. The study group demonstrated statistically significant improvements in mean values for the IKDC (Δ20.6 ± 19.3, P < 0.001) and KOOS JR (Δ18.1 ± 19.6, P < 0.001) from baseline to a minimum of two years after HTO.

### Table 1

Demographic and intraoperative characteristics of the study population.

| Symptom | Symptom > 2 yrs | All Patients | P-value |
|---------|-----------------|--------------|---------|
| (< 2 yrs) (N = 17) | (N = 24) | (N = 41) |
| **Age (yrs)** | 36.2 ± 9.4 | 37.7 ± 7.4 | 37.0 ± 8.2 | 0.590 |
| **BMI (kg/m²)** | 27.4 ± 3.4 | 27.8 ± 4.8 | 27.6 ± 4.2 | 0.770 |
| **Female sex** | 6 (35.3) | 6 (25.0) | 12 (29.3) | 0.501 |
| **Follow up (months)** | 49 (24–105) | 48 (24–87.5) | 48.5 | 0.670 |

Follow up is reported as median (interquartile range). All Patients (N = 41) presented as median (IQR) due to non-normal data distribution.

| Concomitant procedures | OCA | OAT | ACI | MFx | ACLR | Revision ACLR | Meniscal transplant |
|------------------------|-----|-----|-----|-----|------|---------------|-------------------|
| **Frequencies** | 9 (52.9) | 1 (5.9) | 0 (0.0) | 1 (5.9) | 1 (5.9) | 3 (17.6) | 3 (12.5) | 6 (14.6) |
| **Relative** | 35.3 | 4.2 | 0.0 | 4.2 | 4.2 | 17.6 | 12.5 | 14.6 |

Follow up is reported as median (interquartile range). All Patients (N = 41) presented as median (IQR) due to non-normal data distribution.

| Medial JSW (mm) | AP x-ray (N = 40) | PA x-ray (N = 30) | Degree of correction (°) |
|----------------|------------------|------------------|-------------------------|
| **Lateral** | 4.56 ± 1.61 | 5.39 ± 1.23 | 7.5 (7.5–10.0) |
| **Central** | 6.09 ± 1.85 | 6.26 ± 1.25 | 9.0 (7.5–10.5) |
| **Medial** | 6.53 ± 2.14 | 7.06 ± 1.42 | 9.0 (7.5–10.0) |
| **Varus** | 21.1 | 21.3 | 0.063 |
| **Malalignment** | 23.1 | 6.26 | 0.077 |
| **Degree of correction (°)** | 7.5 (7.5–9.0) | 9.0 (7.5–10.5) | 0.063 |

Follow up is reported as median (interquartile range). All Patients (N = 41) presented as median (IQR) due to non-normal data distribution.

Preoperative symptom duration stratification and outcome comparison

Of the 41 patients included in analysis, 24 (58.5%) reported experiencing pain and functional symptoms for a duration of two years or greater. There were no significant differences in baseline demographic, radiographic or intraoperative procedures between patients with preoperative symptom durations greater than and less than two years (Table 1). Both study groups of patients with knee-associated symptoms for greater than and less than two years demonstrated significant improvements in mean values for the IKDC (Δ20.6 ± 19.3, P < 0.001) and KOOS JR (Δ18.1 ± 19.6, P < 0.001) from baseline to a minimum of two years after HTO.
were observed between patients with symptom durations greater than and less than two years in terms of objective clinical outcomes (Table 2).

Pearson’s correlation coefficients were used to determine the association between baseline patient demographics and patient-reported and objective clinical outcomes (Table 3). This analysis revealed that patient characteristics correlated with future conversion to TKA were greater age (r = 0.344, P = 0.027) and higher body mass index (r = 0.320, P = 0.044). Greater age was also negatively correlated with undergoing at least one reoperation (r = –0.381, P = 0.014).

Discussion

The main findings of the current study were that patients who experienced symptomatic medial knee overload/OA for two or greater years prior to HTO did not have inferior outcomes on the IKDC, KOOS JR, PROMIS PI and PROMIS PF measurement tools. Furthermore, patients with preoperative symptom duration greater than two years demonstrated no significant differences in reoperations, time-to-reoperation or conversion to TKA relative to patients with symptom duration less than two years. In addition, there were statistically significant correlations between greater age and BMI with conversion to TKA; however, these correlations were relatively weak in magnitude.

The impact of preoperative symptom duration on postoperative outcomes has not previously been evaluated in the context of HTO; however, this clinical consideration has been investigated in other domains of orthopaedic surgery with mixed results. Theunissen et al. [17] demonstrated that prolonged injury-to-surgery time was significantly associated with a higher level of kinesiophobia three months after anterior cruciate ligament reconstruction. Kunze et al. [9] retrospectively analysed a cohort of 310 patients who underwent primary hip arthroscopy for femoroacetabular impingement syndrome and found those with symptom duration greater than or equal to two years had inferior PROs at five-year follow-up. In contrast, Movassaghi et al. [11] demonstrated that preoperative symptom duration greater than one year did not significantly impact PRO scores, reoperation rates or satisfaction at an average of two years after lumbar decompression surgery. Similarly, preoperative symptom duration did not significantly impact PRO or surgical outcomes at mid-term follow-up after anterior cervical disectomy and fusion [10]. The present study found that patients with a preoperative duration of symptoms of two years or greater did not experience inferior PROs at a minimum of two years after HTO relative to patients with shorter symptom duration. The variable impact of preoperative symptom duration on postoperative outcomes in the orthopaedic literature may be reflective of both procedure-specific and temporal components of this clinical variable. Furthermore, symptom duration is a self-reported patient variable and is therefore susceptible to recall bias. Despite this, these findings represent potentially useful information for preoperative counselling, controlling patient expectations, and informing conservative treatment regimens prior to HTO.

In addition, the present study found no significant differences in reoperations, time-to-reoperation or conversion to TKA on the basis of preoperative duration of symptoms. Conversion to TKA in the present cohort was 7.3%, which is in accordance with the 5- and 10-year HTO survival rates reported in the literature [18,19]. Interestingly, in the current study, both greater age and BMI were correlated, albeit weakly, with HTO failure and subsequent conversion to TKA. The negative impact of greater age and BMI on HTO outcomes has been previously reported in the literature. Hui et al. [20] examined a consecutive series of 413 patients at a mean follow-up of 12 years after HTO and demonstrated that age less than 50 years and BMI less than 25 were associated with greater odds of HTO survival. The positive association between age less than 50 years and long-term HTO survival has also been corroborated in other studies [21–23]. It is possible that younger patients experience quicker and more complete recoveries after HTO, ultimately yielding greater satisfaction and physical functionality in the long term. Similarly, the

Table 2

| Symptom duration | Symptom < 2 yrs (N = 17) | Symptom > 2 yrs (N = 24) | All Patients (N = 41) | P-value |
|------------------|--------------------------|--------------------------|----------------------|---------|
| Patient-reported outcomes |                         |                          |                      |         |
| Preoperative |                         |                          |                      |         |
| IKDC            | 33.3 ± 15.2              | 42.1 ± 14.8              | 38.9 ± 15.2          | 0.179   |
| KOOS JR         | 47.7 ± 21.2              | 55.4 ± 12.4              | 52.4 ± 16.5          | 0.270   |
| Postoperative   |                         |                          |                      |         |
| IKDC            | 61.3 ± 18.2              | 58.8 ± 22.7              | 59.8 ± 20.7          | 0.700   |
| KOOS JR         | 69.4 ± 14.8              | 69.4 ± 20.5              | 69.4 ± 18.3          | 0.091   |
| PROMIS PI       | 56.1 ± 7.5               | 56.3 ± 9.6               | 56.2 ± 8.5           | 0.971   |
| PROMIS PF       | 46.9 ± 4.7               | 45.8 ± 9.1               | 46.4 ± 7.2           | 0.071   |
| Delta (pre-to-post change) |                 |                          |                      |         |
| IKDC            | 28.5 ± 14.5              | 16.1 ± 20.6              | 20.6 ± 19.3          | 0.093   |
| KOOS JR         | 24.7 ± 22.0              | 13.8 ± 17.2              | 18.1 ± 19.6          | 0.162   |

Objective clinical outcomes

| Minimum of one reoperation (%) | 8 (47.1) | 10 (41.7) | 18 (43.9) | 0.981 |
| Two or more reoperations (%)  | 1 (5.9)  | 3 (12.5)  | 4 (9.8)   | 0.629 |
| Time to first reoperation (months) |          |          |          |       |
| Conversion to TKA (%)          | 1 (5.9)  | 2 (8.3)   | 3 (7.3)   | 1.000 |

Percentages are relative to the total number of patients in each cohort.

Abbreviations: IKDC, International Knee Documentation Committee score; KOOS JR, Knee Injury and Osteoarthritis Outcome Score for Joint Replacement; PROMIS PI, Patient-Reported Outcome Measurement Information System Pain Interference; PROMIS PF, Patient-Reported Outcome Measurement Information System Physical Function; TKA, total knee arthroplasty.

* Presented as median (IQR) due to non-normal data distribution.

two or more reoperations, conversion to TKA) outcomes when the duration of symptom cut-off was 18- or 36-months. Given the modest sample size of the present study, a post-hoc power analysis was conducted to determine the sample size required to reach statistical significance. Using the mean delta IKDC scores and standard deviations calculated in the present analysis, with an alpha value of 0.05 and sample size of 41, the estimated power was 0.57. The power analysis indicated that a total sample size of 68 patients (34 in each group) would be necessary to attain a power of 0.80 and alpha value of 0.05.

Of the entire study population, 18 (43.9%) patients underwent a minimum of one reoperation at a median (IQR) time of 18.5 (9.25–31.0) months. Of these 18 patients, five underwent general articular cartilage debridement, four had hardware removal, two had intraarticular debridement and hardware removal, two had OCA with MAT, one had a medial and lateral meniscectomy, one had a partial articular debridement with removal of tibial plate and screws, one had an OCA with tibial tubercle osteotomy, one had a medial meniscectomy with hardware removal and one had an ACL reconstruction. Four (9.8%) patients had two or more reoperations. A total of three (7.3%) patients converted to TKA during the follow-up period. No statistically significant differences

Table 3

| Symptom duration | Greater age | Female sex |
|------------------|-------------|------------|
| Postop IKDC      | r = 0.063   | r = –0.185 | r = –0.112 |
| Postop KOOS JR   | r = –0.025  | r = –0.172 | r = 0.028  |
| At least one reoperation | r = –0.381  | r = –0.009 | X² = 0.026 |
| Two or more reoperations | r = –0.113  | r = 0.067  | X² = 1.834 |
| Time to first reoperation | r = –0.018  | r = 0.217  | r = –0.231 |
| Conversion to TKA | r = 0.344   | r = 0.320  | X² = 1.339 |

Bold values indicate statistical significance (P < 0.05).

Abbreviations: IKDC, International Knee Documentation Committee score; KOOS JR, Knee Injury and Osteoarthritis Outcome Score for Joint Replacement; TKA, total knee arthroplasty; BMI, body mass index.
negative association between overweight BMI and long-term HTO survival has been well established [20,21,24–26]. Given the strong link between obesity and risk for knee OA [27,28], overweight BMI may cause pathologic forces on the knee joint and result in greater damage to the articular cartilage relative to those with normative BMIs. Consequently, earlier and more frequent HTO failure in patients with higher BMIs would not be unexpected.

There are several limitations of the present study that must be considered when interpreting the results. First, the present study was conducted in a retrospective manner and had a low responder rate for postoperative surveys (38.3%). This may have biased the results in favour of those patients choosing to complete the postoperative questionnaires. Second, the onset of medial knee overload/OA symptoms was self-reported by patients and therefore subject to recall bias. However, symptom onset was extracted along with clinical notes where possible to minimize the risk of bias. Third, the small sample size precluded the ability to perform more complex statistical modelling controlling for covariates when evaluating the effect of preoperative symptom duration; however, the absence of significant baseline differences in demographics, radiographic measurements, PROs and postoperative follow-up time between patients with symptom durations of greater and less than two years increases confidence in this comparison. Despite this, post-hoc power analysis indicated that the statistical comparison of the primary outcome of delta IKDC score was underpowered due to the inclusion of only 41 patients. Future studies with larger sample sizes are necessary to corroborate the findings of the present study in terms of the impact of preoperative duration on symptoms. Fourth, the average age of the study cohort (37.0 ± 8.2 years) was younger than previous literature [2,6]. It is possible that younger patients have higher expectations for pain and functional improvement after HTO which may limit the generalizability of the present findings. Fifth, a substantial proportion of the study cohort underwent concomitant cartilage restoration and ligamentous/meniscal procedures in addition to HTO. A total of 13 (31.7%) patients in the cohort underwent isolated HTO for treatment of osteoarthritis. Due to the nature of these procedures frequently being performed in a combined approach [29], the impact of isolated HTO is unclear. Lastly, there are a potentially large number of other risk factors influencing HTO failure that were not evaluated in the present study, including prior knee surgeries, MCL and ACL laxity, and preoperative range of motion among others [20]. However, the main purpose of this study was to assess the impact of preoperative symptom duration on postoperative outcomes at mid-term follow-up after HTO because this clinical consideration has not been previously investigated to our knowledge.

Conclusion

Patients with a preoperative duration of symptomatic medial knee overload/arthritis of two years or greater do not experience inferior PRO or clinical outcomes than patients with a symptom duration of less than 2 years at mid-term follow-up. Greater age and BMI were weakly correlated with conversion to TKA. Greater age was negatively correlated with undergoing at least one reoperation.

Ethics approval

Rush University Medical Center IRB # 19082302.

Declaration of competing interest

One or more of the authors has declared the following potential conflict of interest or source of funding: A.B.Y. reports personal fees from CONMED Linvatec, personal fees from JRF Ortho, personal fees from Olympus, grants from Organogenesis, non-financial support and other from Patient IQ, non-financial support from Smith & Nephew, non-financial support from Sparta Biomedical, grants from Vericel, and grants from Arthrex, Inc., outside the submitted work; B.F. reports personal fees from Elsevier, personal fees from Arthrex, Inc., personal fees from Jace Medical, grants from Smith and Nephew, personal fees from Stryker, and grants from Ossur, outside the submitted work; B.J.C. reports other from Aesculap/B.Braun, other from the American Journal of Orthopaedics, other from the American Journal of Sports Medicine, grants, personal fees, non-financial support and other from Arthrex, Inc., other from the Arthroscopy Association of North America, other from Athletico, other from Cartilage, other from Elsevier Publishing, other from the International Cartilage Repair Society, other from the Journal of Shoulder and Elbow Surgery, other from the Journal of the American Academy of Orthopaedic Surgeons, other from JRF Ortho, other from the National Institutes of Health (NIAMS & NICHD), other from Operative Techniques in Sports Medicine, other from Ossio, personal fees and other from Regentis, other from Smith & Nephew, personal fees and other from Zimmer, outside the submitted work; J.C. reports personal fees and other from Arthrex, Inc., personal fees and other from Smith & Nephew, and personal fees from CONMED Linvatec, outside the submitted work.

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