Total knee arthroplasty (TKA) is a well-recognized procedure for the treatment of severe degenerative arthritis of the knee. The beneficial effects of this procedure have led to its increased use during the past several decades.\(^1,2\) One study projects that the demand for primary TKA will increase 673% by the year 2030.\(^3\)

In addition, many patients have focal articular cartilage defects that are amenable to joint preservation. A common treatment for these lesions is microfracture (MFX) due to the minimally invasive approach, cost-effectiveness, and technical simplicity.\(^4-6\) The optimal indication is a young, active patient (<40 years old) with a smaller lesion (<2 to 3 cm\(^2\)).\(^7\) The resultant repair tissue is primarily fibrocartilage, which has been shown to be biomechanically inferior to hyaline articular cartilage. Consequently, studies have demonstrated clinical improvement at 2 years but eventual deterioration at long-term follow-up.\(^8-10\)

Progressive arthritis and subsequent arthroplasty after knee arthroscopy have
been well documented.\textsuperscript{11-14} Analysis of a private-payer database found that 5.2% of patients underwent knee arthroplasty at 5 years after any arthroscopic procedure.\textsuperscript{12} A retrospective study of TKA after previous knee arthroscopy demonstrated a higher rate of complications and failure compared with primary TKA alone.\textsuperscript{14} However, a lack of data are available on the natural history of failed MFX, and specifically on those patients who require TKA for generalized arthritis. One study demonstrated that 5.9% of patients with prior MFX required either revision MFX or TKA after a mean of 23 months.\textsuperscript{13} Considering that more than 25,000 MFX procedures are performed in the United States every year, the number of these patients that will undergo future TKA is significant.\textsuperscript{15}

The purpose of this study was to compare the results of TKA in patients with and without previous MFX to determine (1) clinical outcomes, (2) complications and reoperations, and (3) factors that may influence outcome.

\textbf{MATERIALS AND METHODS}

The authors identified all patients at their institution with a history of MFX surgery who underwent primary unilateral TKA on the same knee during 2005 to 2014. The local institutional review board approved this retrospective comparison cohort study protocol (IRB \#15-000601). The records were reviewed for age at the time of MFX and TKA, sex, body mass index (BMI) at time of TKA, preoperative and postoperative Knee Society Score (KSS) (Subjective [KSS-S] and Function [KSS-F]), implant type, pre- and postoperative range of motion (ROM), previous surgeries, and postoperative complications (including revision TKA, periprosthetic joint infection, and deep venous thrombosis), and reoperations. Twenty-one TKA patients with a history of MFX surgery at the authors’ institution or elsewhere were identified. These patients were matched in a 2:1 fashion (total n=63) based on age at TKA (within 5 years), sex, BMI (within 5 kg/m\textsuperscript{2}), surgeon, and implant. Radiographs prior to TKA in both groups were analyzed for arthritic changes using the Kellgren-Lawrence grading system.\textsuperscript{16} Failure was defined as revision arthroplasty for any reason.

\textbf{Power Analysis}

An a priori power analysis was performed to determine the sample size using a 2-sided hypothesis test at an alpha level of 0.05, a power of 0.8, a sample proportion of 2:1 in the matched cohorts, and a hazard ratio of 2.5. For a survival analysis with a hazard ratio of 2.5, forty-three patients would be needed to show significance between cumulative survival between cohorts.

\textbf{Statistical Analysis}

Patient criteria with continuous measures were reported as mean±SD as a measure of variability, accounting for sample size in each cohort. Continuous data were evaluated using the Student’s \textit{t} test to compare means while accounting for sample size and variability. Categorical data was evaluated using chi-square analysis. To assess the relationship between various risk factors on clinical outcomes (KSS-S and KSS-F scores) of TKA after MFX, a standard least-squares multivariate model was constructed due to the continuous nature of the dependent variables. Characteristics analyzed included age at the time of surgery, sex, BMI, pre-TKA range of motion, and Kellgren-Lawrence grade. Two-degree factors in the multivariate analysis were also assessed for possible pairwise interactions between variables. An analysis of covariance was used to account for baseline differences between cohorts. All analyses were performed using JMP version 7 software (SAS Institute, Inc, Cary, North Carolina), with \textit{P}<0.05 being significant.

\textbf{RESULTS}

\textbf{Patient and Operative Characteristics}

Patient characteristics are reported in the Table. In the MFX group, the mean time from MFX to index TKA was 8.0 years (range, 0.7-25.9 years). Mean overall time from index TKA to last follow-up was 4.7 years (±4.4). In the MFX group, mean age at TKA was 54.7 years (range, 40-71 years), with 11 women and 10 men included. Mean BMI was 33.2 kg/m\textsuperscript{2} (range, 17.2-47.3 kg/m\textsuperscript{2}). Of the 11 patients who had a recorded MFX location, 81% were femoral condylar and 19% were patellofemoral. In the control group, mean age at TKA was 55.4 years (range, 41-74 years), with 22 women and 20 men included. Mean BMI was 32.8 kg/m\textsuperscript{2} (range, 19.7-42.3 kg/m\textsuperscript{2}).

Patients in both the MFX and control groups were treated with a posterior-stabilized cemented implant and patellar resurfacing.

\textbf{Preoperative Radiographs}

Radiographs were assessed using Kellgren-Lawrence grades. In the MFX group, 67% were classified as grade 3 and 33% as grade 4 compared with 35% grade 3 and 65% grade 4 in the control group (\textit{P}=.02).

\textbf{Clinical Outcomes}

The preoperative to final follow-up change in KSS-S (\textbf{Figure 1A}) and KSS-F (\textbf{Figure 1B}) values were assessed for both the prior MFX and control groups.

Mean KSS-S in the MFX group increased from 52.9 (±10.6) preoperatively to 77.6 (±14.9) at final follow-up (\textit{P}<.01). In the control group, mean KSS-S improved from 51.3 (±13.3) to 83.8 (±12.7; \textit{P}<.01). The improvement of 24.7 points (±18.5) in the MFX group was significantly less than the improvement in the control group (32.5±18.1; \textit{P}<.01). The MFX group demonstrated an improvement in mean KSS-F scores from 63.0 (±13.5) to 88.9 (±13.8), whereas the control group demonstrated an improvement from 52.4 (±18.6) to 87.1 (±16.6) (\textit{P}<.02). The improvement in KSS-F scores in the MFX group (24.7±18.0) was significantly less than the improvement in the control group (32.5±20.1; \textit{P}=.02).
Failure

Failure, defined as revision arthroplasty for any reason, was seen in 4.8% (n=1) of the MFX patients and 2.4% (n=1) of the control group at 5-year follow-up. The single MFX patient underwent an isolated tibial liner exchange 4.9 years after primary surgery revision surgery for polyethylene wear. At final follow-up, there was one additional failure in the control group. One patient in the control group underwent revision arthroplasty due to aseptic loosening of both the femoral and tibial components at 4.1 years after initial TKA. A second patient had an isolated tibial liner exchange 13.3 years after index surgery for polyethylene wear.

Complications

One MFX patient with arthrofibrosis required manipulation under anesthesia less than 3 months after initial arthroplasty. Knee flexion improved from 65° to 120°. No cases of arthrofibrosis were identified in the control group.

Risk Factor Analysis

Older age at the time of surgery associated with a 1.7-point reduction in KSS-S score (95% confidence interval [CI], -2.5 to -0.9) (Figure 2). Increasing pre-TKA ROM was associated with a 0.6-point improvement in KSS-S score (95% CI, 0.1 to 1.2). The combination of worse preoperative ROM and increased age at the time of TKA demonstrated a smaller improvement in KSS-S score. Body mass index and sex had no individual relationship with KSS-S score change; however, increased BMI in female patients was significant, with an increase of 1.9 points (95% CI, 0.4 to 3.3). None of the variables had significant individual or pairwise interactions with a change in KSS-F scores from preoperative to final follow-up.

Discussion

Microfracture is a relatively common procedure, with 25,000 cases performed annually in the United States. Unfortunately, a significant proportion of these procedures will deteriorate over time and many patients will develop severe arthritis leading to TKA. Clinical results of TKA in patients with a history of MFX are unknown. This retrospective comparative study showed that there was significant overall improvement after TKA in the setting of prior MFX and a matched cohort. However, there is a slightly inferior change in KSS scores in patients with prior MFX.

Primary TKA is a reliable procedure for the improvement of pain and function.17,18 A retrospective study compared the results of TKA in patients with prior bony or soft tissue surgical procedures with primary TKA without prior proce-
dures. The International Knee Society (IKS) score and postoperative knee flexion improved in all groups. The IKS knee score improvements were lower in the groups with prior procedures, with the soft tissue procedure group showing the smallest IKS change. A study of patients with a history of 2 or more arthroscopic procedures before TKA did not show a difference in KSS score improvement compared with primary TKA without prior procedures.20

One matched study of primary TKA showed inferior improvement in patients with preoperative stiffness.21 This observation does not apply to the current MFX group because there was no difference in ROM when compared with the control group, although 1 MFX patient developed arthrofibrosis. Conversely, another matched TKA cohort study did not find a difference in clinical improvement between stiff and non-stiff knees.22 The outcome variability between these studies may be accounted for by inconsistent definitions of knee stiffness.

An interesting finding in the current study is that the MFX group had a lower Kellgren-Lawrence grade preoperatively compared with the control group prior to undergoing TKA. A previous survey reported the belief of orthopedic surgeons that patients with more severe radiographic arthritis had a higher likelihood of an excellent outcome.23 A study of 256 patients assessed functional outcomes based on Kellgren-Lawrence grades and found that increasingly severe arthritis based on radiographs resulted in superior improvements.24 However, a recent article did not demonstrate a good correlation of successful outcome with minimal preoperative radiographic arthritis. The authors found that patients with less severe preoperative radiographic arthritis did as well as the control group with severe arthritic changes on preoperative radiographs.25 A study of patients with unexplained, persistent pain after TKA demonstrated that those with early-grade preoperative arthritis are at increased risk for pain.26 However in these studies, “early-grade” and “less-severe” were defined as Kellgren-Lawrence grades 1 and 2, respectively. Although none of the patients in the current study would be considered early-grade by this definition, it may still affect patient outcome.

Similar outcome improvement would be expected in both groups, considering the MFX patients undergo total resurfacing with TKA. However, there is less improvement in KSS scores in the MFX group. These patients may have increased baseline pain that manifests as persistent pain and decreased function even after TKA. A study of 139 patients demonstrated that prior knee surgery increases the prevalence of neuropathic pain in patients with knee osteoarthritis.27 In addition, a study of mice with OA found major nociceptive pain receptor regulation in articular cartilage of damaged knees.28

Addressing neuropathic pain and other causes, such as psychological factors, are important in managing patients with OA with prior knee surgery.29 One study of more than 8000 TKA cases demonstrates that increased pain and function scores pre-TKA result in decreased patient satisfaction and outcome.30 It is important to consider these factors to optimize outcome in patients with prior MFX.

Revision-free survival was 97.6% at 5 years and 95.2% at 13 years after index TKA for patients in the control group that did not undergo previous MFX. These results are consistent with other large studies of primary TKA who have demonstrated survivorship between 91% and 100% after 10 years of follow-up and 71% after 20 years of follow-up.17,18,31,32

The implications of previous surgery on the results of TKA have been reported. A study of 1036 patients with a proximal tibial osteotomy before TKA found survivorship to be 91.8% at 10 years and 88.4% at 15 years.33 In a study of prior soft tissue procedures with 10 years of follow-up, a significantly higher number of postoperative complications and an insignificantly lower survivorship rate (94.8% vs 98.1% in the control group, respectively) were identified.19 A study of 35 knees with osteochondral allograft transplantation before TKA demonstrated a 17% revision rate due to aseptic loosening.34 In the current series, 1 (5%) patient with prior MFX developed polyethylene wear requiring tibial liner exchange at 5 years. A higher complication rate has been associated with primary TKA performed within 6 months of an arthroscopic procedure.35 However, 2 or more arthroscopic procedures before TKA does not appear to affect implant survival.20

Several studies have reported negative outcomes after knee arthroplasty with associated factors, such as prior surgery, obesity, and the female sex.36-38 One study found that those with prior knee joint surgery were more likely to undergo TKA, and most of these patients were women.39

Figure 2: Multivariate analysis for Knee Society Score Subjective (A) and Function (B) values.
In addition, a survey of more than 48,000 patients who underwent hip and knee arthroplasty showed women to have worse symptoms and greater disability compared with their male counterparts, whereas another study reported that women had more pain and poorer function than men. The current authors’ results showed that the combination of female sex and increased BMI in TKA patients with a history of MFX group have less improvement in KSS-S scores.

This study has both limitations and strengths. The retrospective design and small sample size result from the well-defined scope. The small number of failures did not allow for a meaningful Kaplan-Meier survival curve to be constructed. Multiple other potential variables other than prior MFX may predispose patients to knee arthritis and affect outcome. Finally, the cohorts have short-term follow-up, which could allow for differences in prosthesis survivorship over a larger period. An important strength of this study is the matched control group, which allowed for direct comparison of patients with minimal variation in baseline demographic characteristics.

**Conclusion**

Total knee arthroplasty in patients with a previous MFX results in good pain relief and improved function. Implant survivorship is similar between groups, but the MFX patients have slightly less clinical improvement compared with a matched control group, possibly due to underlying patient factors. The results of this study are not able to implicate a history of MFX as a predictor of inferior TKA outcome.

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