Total knee arthroplasty (TKA) is an effective option in the treatment of osteoarthritis of the knee. The longevity of a successful TKA is limited primarily by component durability, which has improved considerably during the past few decades. Some studies have reported survivorship of TKAs exceeding 90% at 15 years. However, stiffness remains an occasional problematic outcome of TKA. Kim et al defined post-TKA stiffness as a flexion contracture of 15° and/or less than 75° of flexion. With this definition applied to the 1000 TKAs in their study, 1.3% of knees were complicated by stiffness. In a series of 1188 TKAs, Yercan et al found the prevalence of stiffness after TKA to be 5.3% at a mean follow-up of 31 months.
Causes of knee stiffness following a TKA can often be identified as infection, component loosening, hemarthrosis, insufficient pain control, and inadequate postoperative rehabilitation. In cases where knee stiffness cannot be attributed to a definitive cause, arthrofibrosis is considered.

Arthrofibrosis as a cause of stiffness following a TKA has been reported to occur in as many as 6% of patients. It results from the build-up of dense fibrous connective tissue within the joint that ultimately diminishes range of motion (ROM) and causes discomfort. When alternative causes are excluded or stiffness persists, several treatment modalities are available. Nonoperative options include pain management, physical therapy, and manipulation under anesthesia. Surgical options include open or arthroscopic lysis of adhesions and TKA revision.

Arthroscopic lysis of adhesions in the treatment of arthrofibrosis following TKA has gained favor in recent years for its effectiveness and minimal invasiveness. Lysis of adhesions is well suited for releasing adhesions that are most commonly found between the capsule and the femoral condyles as well as in the anterior interval, infrapatellar fat pad, and pretilial recess. The primary limitation of arthroscopic lysis of adhesions discussed in the literature is difficulty releasing posterior capsular adhesions—a feat even less tenable with manipulation under anesthesia alone. This difficulty in arthroscopically accessing the posterior capsule and releasing adhesions in this location often results in persistent flexion contracture. However, posterior cruciate ligament recession done in cruciate-retaining knees at the time of lysis of adhesions can correct stiffness caused by scarring of the posterior cruciate ligament. Regardless, the procedure’s therapeutic utility coupled with the ability to visualize intra-articular pathology makes arthroscopic lysis of adhesions popular in the treatment of the stiff TKA. The timing of arthroscopic lysis of adhesions is debatable. However, it generally has been reserved for patients who fail to respond to physical therapy and manipulation under anesthesia 3 months after the index TKA. The current authors’ inclusion criteria were somewhat more aggressive, as they indicated arthroscopic lysis of adhesions for patients when 90° ROM was not attainable at 6 weeks postoperatively; however, the mean time from TKA to the actual lysis of adhesions was 117 days.

**Materials and Methods**

Institutional review board approval was obtained prior to conducting this work. The authors retrospectively reviewed the records of patients who underwent TKA performed by the senior author (E.H.A.) and who subsequently underwent arthroscopic lysis of adhesions between 2013 and 2016 for the treatment of knee stiffness. During this period, 121 TKAs (15 of which were revisions) and 58 lysis of adhesions procedures were performed. Seventeen patients receiving primary TKA underwent lysis of adhesions. One additional patient having a revision TKA in the setting of a prior infected TKA treated by another orthopedic surgeon with explant, antibiotic spacer, and intravenous antibiotics for 8 weeks who developed stiffness was included. Patients with suspected infection did not undergo a lysis of adhesions and were thus excluded. Stiffness was defined as failing to meet 90° ROM at 6 weeks postoperatively from the initial TKA. The authors excluded patients for whom knee stiffness could be attributed to causes other than arthrofibrosis.

All patients with stiffness in the setting of TKA were evaluated with the following: complete blood count with differential panel, erythrocyte sedimentation rate, and C-reactive protein. If infection was suspected or white blood cell count, erythrocyte sedimentation rate, or C-reactive protein was markedly elevated, synovial aspirations of the knee were performed in a sterile environment and specimens underwent standard evaluation of cell count, crystals, and cultures with Gram stain. Patients with clinical signs and symptoms of septic TKA in the acute setting with or without adjunctive test results showing a synovial white blood cell count of greater than 1100 cells/µL or a polymorphonuclear cell percentage of greater than 64% were considered infected. They were treated with either incision and drainage with polyethylene liner exchange, if the signs and symptoms occurred within 3 weeks of the index TKA, or incision and drainage, explant, and antibiotic spacer placement with 6 to 8 weeks of intravenous antibiotics guided by cultures. During this period, 22 explants with antibiotic spacer placement and 14 polyethylene exchanges were performed.

Once patients were in the operating room and general anesthesia had been administered, an examination under anesthesia was performed. Each patient was fitted with a proximal thigh tourniquet. After standard surgical site preparation and draping, the legs were exsanguinated with an Esmarch bandage. Arthroscopes were introduced into the intercondylar notch via an inferolateral arthrotomy, and an arthroscopically guided medial arthrotomy was then developed to introduce a shaver or radiofrequency device in mid-flexion. An additional superolateral arthrotomy was performed for improved visualization at any point if it was needed. First, any adhesions surrounding the femoral component were addressed to establish landmarks. Anterior adhesions were then addressed by sweeping medially and laterally, which allowed visualization of the peripatellar region and the suprapatellar pouch. Adhesions were completely removed within the suprapatellar pouch. Next, the medial and lateral gutter adhesions were lysed or ablated via radiofrequency. Lateral retinacular release was performed as needed in 1 patient to improve patellar tracking. Any remnant infrapatellar fat pad was then lysed to open up the pretilial recess. Further anterior adhesions were released at this point. At
the conclusion of the lysis of adhesions, inspection of the femoral component, the implant–cement–bone interface, and the polyethylene component was performed. Additional irrigation was run through the knee to remove any remaining free bodies or debris. Manipulation under anesthesia was performed for each patient following lysis of adhesions with only slight pressure on the tibial tubercle to avoid disruption of the extensor mechanism. Standard sterile closure and dressings were applied, and all patients began active and passive ROM exercises immediately postoperatively.

Three men and 15 women underwent the procedure. They had an average age of 55.7 years (range, 48-69 years) and an average body mass index (BMI) of 36.8 kg/m² (range, 25.2-47.2 kg/m²). The procedure was performed on 10 right and 8 left knees. Mean follow-up was 449 days (minimum, 116 days). The mean time from TKA to arthroscopic lysis of adhesions was 117 days (range, 53-336 days). All TKAs were posterior-stabilized designs.

Prior to arthroscopic lysis of adhesions, all patients followed the same conservative treatment protocol consisting of physical therapy and pain management. Two of the 18 patients had received manipulation under anesthesia between initial TKA and lysis of adhesions. In 1 of the 18 patients examined, arthroscopic lysis of adhesions followed a TKA revision for treatment of a septic TKA initially treated with explantation and antibiotic spacer placement. Another patient in this cohort received a second arthroscopic lysis of adhesions for continued symptoms.

Pre- and postoperative flexion contracture, flexion, ROM arc, and patient-report ed visual analog scale scores for pain were collected. All patients were contacted to complete pre- and postoperative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) surveys. This 24-question patient-reported survey measures patients’ perception of their functional ability. It has been extensively validated during more than 30 years of use and is currently employed in more than 60 languages and shortened forms.16-20 Additionally, patient satisfaction was measured by asking patients 2 questions: “Would you have the surgery again if you were in the same position?” “Are you satisfied with the surgery?”

A 2-tailed Student’s t test (P<.05) was used to compare pre- and postoperative outcomes. Pearson’s correlation coefficient was used to determine associations between patient demographics and outcome data. A multivariate linear regression for modeling change in the outcome measures was used adjusting for age, BMI, time to lysis of adhesions, and weight. McNemar’s test was used to evaluate for marginal homogeneity and with paired dichotomous data. Significance was set at P=.05.

RESULTS

Fifteen of the 18 patients were successfully contacted for collection of WOMAC scores and satisfaction surveys. Statistically significant improvements were noted in all 3 major outcomes measured: ROM, pain, and WOMAC score.

Range of Motion

Flexion contracture, flexion, and ROM arc were examined. There was a mean improvement from pre- to postoperative ROM flexion contracture of 6.11° (P<.05). The mean preoperative ROM flexion contracture was 9.17° (SD=11.79°), and the mean postoperative ROM flexion contracture was 3.06° (SD=5.72°). There was a mean improvement from pre- to postoperative flexion of 29.45° (P<.001). The mean preoperative flexion was 67.22° (SD=22.96°), and the mean postoperative flexion was 96.67° (SD=17.06°). There was a mean improvement from pre- to postoperative ROM arc of 35.56° (P<.001). The mean preoperative ROM arc was 58.05° (SD=25.56°), and the mean postoperative ROM arc was 93.61° (SD=18.53°).

Of note, 1 patient received 2 arthroscopic lysis of adhesions procedures, experiencing a decline in flexion following the first procedure (70° to 40°) but returning to baseline (70°) after the second procedure. For this same patient, outcome measures in flexion contracture and full ROM arc improved after each lysis of adhesions.

Of the 18 patients examined, individual improvements in ROM arc were observed in 17 patients. The 1 patient for whom improvement was not observed experienced no change in ROM arc (80° pre- and postoperatively) and a modest improvement (10° increase) in flexion following arthroscopic lysis of adhesions. This same patient experienced a worsened flexion contracture that increased from 0° preoperatively to 10° following the procedure. One other patient developed a 5° flexion contracture following the procedure (from 0° flexion contracture preoperatively). However, both of these patients experienced improvement in flexion and ROM arc as a result of the procedure.

Finally, 2 patients experienced no improvement in preoperative flexion contracture following lysis of adhesions. The first of the 2 had a preoperative flexion contracture of 10°; although this remained following lysis of adhesions, the patient experienced postoperative improvement in flexion and ROM arc. The second of the 2 was the single patient in the cohort who had received a revision TKA. This patient experienced improvement in flexion achieved and full ROM but no change in preoperative flexion contracture (20°). Pre- and postoperative values for ROM flexion contracture, flexion, and total ROM arc are summarized in Figure 1.

Pain

Patient-reported pain scores improved by a mean of 2.17 (P<.001). The mean preoperative pain score was 5.78 (SD=2.49), and the mean postoperative pain score was 3.61 (SD=2.73). Two pa-
Patients experienced worse pain following the procedure. One patient experienced no change from preoperative pain score following arthroscopic lysis of adhesions.

Western Ontario and McMaster Universities Osteoarthritis Index Scores

The mean WOMAC score improved by 32.23% ($P<.001$) postoperatively. The mean preoperative WOMAC score was 75.42% (SD=19.58%), and the mean postoperative WOMAC score was 43.19% (SD=22.75%). All 15 patients for whom WOMAC scores could be collected showed functional improvement by this outcome. Pre- and postoperative WOMAC scores and pain are summarized in Figure 2.

Satisfaction

Fourteen of the 15 patients would undergo the same procedure again if they were in similar circumstances. Thirteen of the 15 patients stated overall satisfaction with the procedure.

Predictors of Success

Predictors of success for arthroscopic lysis of adhesions for the stiff TKA were examined by assessing the patient demographics of age, weight, BMI, and time to lysis of adhesions after TKA. Pearson’s correlation test was performed to measure the relationship between these demographics and the aforementioned outcomes. Earlier lysis of adhesions and improved WOMAC scores ($r=-0.26$), lower BMI and improved pain ($r=-0.43$), lower weight and improved flexion contracture ($r=-0.35$), and younger age and improved WOMAC scores ($r=-0.63$) were correlated. Furthermore, the authors sought to examine correlations between pre-TKA, pre-lysis of adhesions, and post-lysis of adhesions flexion contracture, flexion, and ROM arc. Correlations existed between pre-TKA and post-lysis of adhesions flexion contracture ($r=0.29$), pre-TKA and post-lysis of adhesions flexion ($r=0.18$), pre-TKA and post-lysis of adhesions ROM arc ($r=0.33$), pre-lysis of adhesions and post-lysis of adhesions flexion ($r=0.61$), and pre-lysis of adhesions and post-lysis of adhesions ROM arc ($r=0.65$). These findings indicating the predictive utility of pre-TKA and pre-lysis of adhesions ROM parameters are consistent with previous work.21

Multivariate linear regression was performed for patient demographics and out-
comes as well as ROM parameters. Both lower BMI ($P=0.04$) and lower weight ($P=0.04$) predicted improved WOMAC scores following lysis of adhesions. For ROM parameters, only pre-lysis of adhesions ROM arc trended to predict post-lysis of adhesions ROM arc ($P=0.08$). Patient age and time to lysis of adhesions were not found to predict patient outcomes.

**Discussion**

Arthrofibrosis resulting in knee stiffness can be a debilitating outcome of TKA. Approximately 1% of patients with stiffness after TKA will fail conservative treatments and require surgical intervention as investigated in the current study.\textsuperscript{22,23} Arthroscopic lysis of adhesions represents a less invasive treatment that can be used with or without manipulation under anesthesia and may circumvent the need for open arthrolysis or revision TKA. The arthroscopic nature of the procedure limits instrumentation in the joint while still permitting access to most problematic adhesions.

This retrospective review indicated both the utility and the potential limitations of the technique. On average, patients in this cohort experienced greater final ROM arc, diminished flexion contracture, reduced subjective pain scores, and improved functionality as measured by the WOMAC. Furthermore, most of the patients in the cohort were satisfied with the procedure and would elect to repeat the arthroscopic lysis of adhesions if presented with the same situation again.

This study also highlighted a possible limitation of arthroscopic lysis of adhesions. Flexion contracture is largely attributed to posterior capsular adhesions, which are considerably difficult to access arthroscopically. The 1 patient with unchanged flexion contractures and the 2 patients with worsened flexion contractures following arthroscopic lysis of adhesions likely implicate poor posterior capsule access as a potential shortcoming of the procedure. Notably, some authors have found success in treating flexion contractures with posterior cruciate ligament recession. As all patients in this series received posterior-stabilized TKAs, this was not an option. Regardless, flexion contractures significantly improved following lysis of adhesions by 6.11° ($P<0.05$).

Higher patient weight and BMI both correlated with worse WOMAC scores on multivariate regression. Pearson’s correlation also showed relationships between earlier lysis of adhesions and improved WOMAC scores ($r=0.26$), lower BMI and improved pain scores ($r=-0.43$), lower weight and improved flexion contracture ($r=-0.35$), and younger age and improved WOMAC scores ($r=-0.63$). On the basis of these data, surgeons would expect patients with lower BMIs or weights to have better patient-reported outcomes and pain control and less severe flexion contractures after undergoing arthroscopic lysis of adhesions. The authors also observed that younger patients had better patient-reported outcomes. On the basis of the trends seen in this study, earlier arthroscopic lysis of adhesions may improve patient outcomes. This is an interesting finding because arthroscopic lysis of adhesions has traditionally been reserved for patients who fail physical therapy and manipulation under anesthesia after 3 months.\textsuperscript{14} In this study, arthroscopic lysis of adhesions was performed if patients were unable to obtain 90° ROM at 6 weeks. The earliest lysis of adhesions occurred at 53 days (mean, 117 days).

There were no other complications in this cohort. However, its small size limited detection of potential complications, including deep venous thrombosis, pulmonary embolism, infection, prolonged drainage, ligamentous injury, and complications associated with anesthesia risk.

Pre-TKA and pre-lysis of adhesions ROM parameters were found to be statistically significant predictors of post-lysis of adhesions ROM parameters. Pre-lysis of adhesions flexion and ROM arc were the strongest predictors of post-lysis of adhesions flexion and ROM arc by Pearson’s correlation ($r=0.61$ and 0.65, respectively). With multivariate regression, this trend was observed; however, the relationship between pre-lysis of adhesions ROM arc and post-lysis of adhesions ROM arc failed to reach statistical significance ($P=0.08$). The correlation was likely not statistically significant because of small sample size. The trend, however, may well be clinically significant and could reach statistical significance in a larger study cohort. In the TKA literature, it has been observed that the pre-TKA ROM predicts the post-TKA ROM.\textsuperscript{21} The current authors believe further work with larger prospective data may be warranted to determine if pre-lysis of adhesions ROM arc significantly predicts post-lysis of adhesions ROM arc.

Most data on arthroscopic lysis of adhesions have been presented in case series, limiting their power. However, the current findings are consistent with previously reported data. Most series have examined ROM in addition to an assortment of functional knee scores. Case series by Jerosch et al\textsuperscript{7} and Klinger et al\textsuperscript{24} examined 32 and 27 patients, respectively, who underwent arthroscopic lysis of adhesions for stiffness. Using the Knee Society clinical rating system, 66% to 78% were considered successful, with improvement from 70 to 71 preoperatively to 85 to 86 postoperatively for the joint subscore, from 68 to 69 preoperatively to 83 to 85 postoperatively for the functionality subscore, and from 30 to 32 preoperatively to 41 to 42 postoperatively for the pain subscore.\textsuperscript{7,24} Arbuthnot and Brink\textsuperscript{5} studied 22 patients using the Oxford Knee Score and showed, on average, an initial improvement of 36.3 to 42.6 after the index procedure and an additional improvement of 29.3 to 36.3 after arthrolysis. They also documented that 36.3% of these patients experienced pain relief, 22.7% continued to have pain, and 41% never had pain.\textsuperscript{5,25} Although these results cannot be directly compared with the results of the current study, 15 (83.3%)
of 18 patients in the current study reported improved pain scores, 1 (5.6%) of 18 reported no change in pain score, and 2 (11.1%) of 18 reported worse pain scores.

Other studies have examined ROM as the primary outcome of interest. Tjoumakaris et al\(^1\) described 39 patients who underwent arthroscopic lysis of adhesions after failed manipulation under anesthesia with posterior-stabilized TKAs. The average arc of motion increased from 62° preoperatively to 98° postoperatively. Flexion contractures were reduced from 16° preoperatively to 4° postoperatively, and flexion improved from 79° preoperatively to 109° postoperatively. A systematic review by Ghani et al\(^2\) on the management of stiff TKAs found that each modality (manipulation under anesthesia, arthroscopic lysis of adhesions, open lysis of adhesions, and revision TKA) led to significant improvement in total ROM (38.4°, 36.2°, 43.4°, and 24.7°, respectively); however, no significant improvement in Knee Society Scores was observed. Tirveilliot et al\(^3\) reported an improvement of 34.2° in total ROM for 62 patients undergoing arthroscopic lysis of adhesions; however, they also noted that patients failed when treated beyond 24 weeks after the index procedure. Similarly, Arbuthnot and Brink\(^4\) and Enad\(^5\) both described failures in patients undergoing arthroscopic lysis of adhesions after 4 months. Furthermore, Arbuthnot and Brink\(^6\) showed a loss of almost half of the initially regained total ROM at 12-month follow-up.\(^7\) Most authors have recommended arthroscopic or open lysis of adhesions 3 months after the initial TKA, whereas the current authors considered patients for arthroscopic lysis of adhesions if they had less than 90° of flexion at 6 weeks. The current authors had successful outcomes with a mean follow-up of 449 days for patients who underwent arthroscopic lysis of adhesions when used for the treatment of a stiff TKA. The technique represents an effective intervention that can be used adjunctively with manipulation under anesthesia, potentially circumventing the need for open arthrolysis or revision TKA. Arthroscopic lysis of adhesions is likely to improve functionality in a stiff TKA. The technique represents an effective intervention that can be used adjunctively with manipulation under anesthesia, potentially circumventing the need for open arthrolysis or revision TKA. Arthroscopic lysis of adhesions is likely to improve functionality in a stiff TKA that has failed more conservative management. Surgical timing and potential predictors of success should be examined further; however, on the basis of these data, younger patients with lower BMI and weight may have improved patient-reported outcomes and pain control. Pre-lysis of adhesions ROM most likely predicts post-lysis of adhesions ROM. Finally, improved outcomes were observed for arthroscopic lysis of adhesions performed earlier after TKA, although larger prospective studies are needed to corroborate these findings.

**REFERENCES**

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