Effect of Medial Epicondylar Osteotomy on Soft Tissue Balancing in Total Knee Arthroplasty

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Abstract

Balancing and surgical exposure of a severe varus knee during total knee arthroplasty (TKA) can be difficult. Use of a medial epicondylar osteotomy to solve these problems has been reported. This study compared knee stability in cadaveric specimens after TKA, after medial epicondylar osteotomy, and after conventional subperiosteal release of the medial collateral ligament (MCL). Five cadaveric knees were tested after TKA, after medial epicondylar osteotomy, and after repair of the osteotomy to compare the results to 5 cadaveric knees that underwent complete subperiosteal release of the MCL. A retrospective review of clinical cases also was performed of 118 varus knees exposed using the standard medial parapatellar approach and subperiosteal release of the MCL to compare results to the literature using a medial epicondylar osteotomy. Coronal and transverse plane laxity increased significantly at 60° and 90° flexion in the knees after medial epicondylar osteotomy. Suture repair of the osteotomy did not affect stability. The knees with MCL release had a significantly lower degree of coronal and transverse plane laxity at 60° and 90° than knees with an epicondylar osteotomy. The retrospective case review found satisfactory exposure and correct ligament balance was achieved in all cases. The findings of this study question the need for an epicondylar osteotomy in severe varus osteoarthritic knees. Because the knee remains unstable in flexion after this technique, an implant with higher constraint should be used.
Most surgeons agree that ligament balancing of the knee with varus deformity should be performed at the time of surgery. Varus deformity often is combined with a fixed flexion contracture, and this combination of deformities may complicate exposure of the medial and posteromedial aspects of the knee. The standard procedure for ligament balancing of the medial side of the knee uses subperiosteal release of the medial collateral ligament (MCL), and this can be accomplished by fractionally releasing only the tight structures in either flexion or extension to avoid excessive ligament release.

However, Engh and Ammeen reported that a medial epicondylar osteotomy could be performed on this type of knee during total knee arthroplasty (TKA) to provide better exposure of the posteromedial corner of the knee joint and also to correct the MCL contracture. Their technique for medial epicondylar osteotomy entails removal of the epicondyle with an osteotome, elevation of a 4×4×1-cm fragment, and eversion of the attachments of the supporting medial structures of the knee. After the TKA is performed, the osteotomy is repaired with 3 sutures across a bony bridge of the distal anteromedial femur to hold the fragment in place. The authors reported a 46% incidence of fibrous union or non-union at the 2-year follow-up with this technique. The knees were stable in full extension and 30° flexion with no significant laxity. Klammer et al. also reported on the use of medial epicondylar osteotomy and advancement to aid in flexion gap balancing in severe varus cases to effectively balance the knee. Their report describes a sliding technique for advancement of medial ligamentous attachments to aid in balancing the knee.

In theory, detaching the entire origin of the MCL, along with the posterior oblique portion of the MCL, would completely destabilize the medial side of the knee. Engh and Ammeen reported that they used a posterior cruciate ligament (PCL)-substituting component for the majority of knees. Resection of the PCL leaves no structure on the medial aspect of the knee for stability, which could be a problem in the postoperative period by increasing the likelihood of instability and dislocation of the posterior-stabilized post.

The authors hypothesized that medial epicondylar osteotomy would destabilize the knee in flexion and extension and the described suture repair would have little or no stabilizing effect postoperatively. The purpose of this study was to investigate the biomechanics of medial epicondylar osteotomy in a cadaveric model in flexion and extension to record the changes in valgus and internal and external rotational stability. These data then were compared with those of a group of cadaveric knees that had an MCL release by subperiosteal release of the tibial attachment. Clinical data of patients with a combined varus and fixed flexion contracture that were corrected by release of the MCL were reviewed retrospectively and compared with the published results of those with a medial epicondylar osteotomy.

**MATERIALS AND METHODS**

**Laboratory Investigation**

Ten normal human cadaver knees were tested for this study. Five specimens were used for a standard MCL release group after TKA, and 5 specimens were used for an epicondylar osteotomy group. Each specimen was prepared by transecting the femur 25 cm proximal to the joint line and transecting the tibia 23 cm distal to the joint. All of the skin and subcutaneous tissues then were removed. The fibula was transected 15 cm from the tip of the fibular head. The femur and tibia were potted in a custom coupling that allowed each specimen to be attached to a custom knee testing device (Knee Data Systems, Little Rock, Arkansas).

The testing device allowed the knee to be placed in any flexion angle. Each knee was tested at 0°, 30°, 45°, 60°, and 90° of flexion for varus and valgus and for internal and external rotational laxity. For varus and valgus testing, each knee was tested to a 10 N-m torque (positive was valgus and negative was varus). The deflection angle at peak torque and the entire load deflection curve were recorded for comparison. For internal and external laxity testing, each knee was tested to 1.5 N-m (external positive and internal negative), and the rotation at peak torque and the load deflection curves were recorded for comparison. The peak angular deflection in both valgus and internal and external rotation was reported as change in laxity.

A TKA through an intermedius approach was performed in all of the knees. Each phase of specimen testing included the protocol listed above for paired comparisons. A Profix (Smith & Nephew, Memphis, Tennessee) TKA system, a standard PCL-retaining implant, was used for all specimens. After the TKA components were in place, the specimens were tested for baseline comparisons. Five specimens were tested with release of the MCL using a half-inch curved osteotome from underneath the periosteal attachment on the tibial aspect of the joint. All tests were repeated. The other 5 knees were tested after performing a medial epicondylar osteotomy using a 1-inch osteotome to create a bone flap measuring approximately 4×4×1-cm. All tests were repeated. The knees with medial epicondylar osteotomy were repaired using 3 sutures through a bony bridge on the anterior aspect of the medial epicondyle using #2 Dexon (Sherwood Medical, St Louis, Missouri), and all tests were repeated.

Valgus and rotational deflection at maximal torque was calculated for all of the groups. Each knee served as its own control, and changes from the normal knee after TKA were calculated for each group studied. A paired t test was performed, and a P value less than or equal to .05 was considered to be statistically significant.
Clinical Series

An effort was made to compare published series using the medial epicondylar osteotomy to knees with similar deformity using the standard medial parapatellar approach to the knee and subperiosteal release of the MCL to achieve ligament balance. A curved half-inch osteotome routinely was used to release subperiostally the insertion of the superficial MCL approximately 8 cm distal to the tibial resection. All knees with varus alignment greater than or equal to 5° and fixed flexion contracture greater than or equal to 15° were reviewed. A total of 118 knees in 102 patients performed from June to December 1998 were available for review with a minimum follow-up of 1 year. Preoperative and postoperative clinical knee and function scores were recorded along with the structures released for ligament balancing and the resulting range of motion and laxity.

RESULTS

Valgus Laxity

Change in laxity was calculated for each group by using the knee values of the intact specimen as a control (Figure 1). When the data from the knees with MCL release were compared with knees in the osteotomy group, no significant differences were noted for full extension (4.3° for the MCL group and 3.8° for the osteotomy group, P= .17) or 30° of flexion (7.7° for the MCL group and 11.6° for the osteotomy group, P=.48).

However, the knees with medial epicondylar osteotomy were significantly more lax than the ligament release group at all other flexion angles tested. At 60°, a significantly greater deflection (P=.05) was measured for the medial epicondylar osteotomy group (20.6°) compared with the MCL release group (8.6°), and at 90°, a significantly greater deflection (P=.04) was observed in the medial epicondylar osteotomy group (16.3°) compared with the MCL release group (7.8°). Knee laxity in the repaired osteotomy group was not significantly different from the unrepaired group at any flexion angle tested. At 90° of flexion, 2 of the 5 knees in both osteotomy groups reached only 5 N-m of torque at maximum deflection of the testing machine (more than 40°).

Internal and External Laxity

Change in rotational deflection was calculated by using the laxity results after TKA as control values for each specimen (Figure 2). In full extension and at 90° of flexion, statistically significant differences in total range of internal and external rotation at the maximum torque values were observed, with greater laxity in the osteotomy groups (P=.05). Differences in rotational laxity at 30° and 60° of flexion were not statistically significant.

Clinical Series

Mean range of motion improved from 80° ± 2.8° preoperatively to 103.6° ± 13.5° postoperatively, and the average flexion contracture was reduced from 21.8° ± 8.8° preoperatively to 2.2° ± 3.3° postoperatively in the 118 knees reviewed in this series. The average clinical knee score was 29.4 ± 15.1 preoperatively and 94.5 ± 3.9 postoperatively. Mean function score improved from 31.4 ± 21.1 preoperatively to 78.3 ± 18.5 postoperatively. Average follow-up was 63.2 ± 32.5 months (range, 3-180 months). Mean preoperative varus deformity was 11.8° ± 9.4°. Intraoperatively, the PCL was balanced for tightness in flexion in 23 knees (19%), and 1 knee (less than 1%) had a PCL release. The MCL was released in 57 knees (48%) along with the posterior capsule on the same side in 30 knees (25%) and the lateral side posterior capsule in 4 knees (3%). The popliteal tendon was released in 20 knees (17%) for tightness that did not allow internal or external rotation about the PCL in flexion.

DISCUSSION

This study sought to compare knee laxity in a cadaveric model using a medial epicondylar osteotomy or traditional ligament releases to treat residual flexion contracture or valgus laxity in flexion. The results supported our hypothesis that laxity and instability would increase significantly in flexion when a medial epicondylar osteotomy is performed compared...
with a more traditional soft tissue release in the cadaveric model.

Knee specimens in the laboratory treated with medial epicondylar osteotomy were significantly more lax in flexion than the standard total knee before release or the cadaveric knee with a complete release of the MCL from the proximal tibia. After the knee was brought from full extension, little support was given to the knee in varus and valgus or internal and external rotation by the remaining posterior capsule and PCL. Although these cadaveric knees did not have a primary fixed flexion and varus contracture, we believe that basic generalizations can be inferred from the results.

The knee specimens with MCL release had much more support in flexion than knees in the osteotomy group. Although the PCL and posterior capsule remained intact in both groups, the osteotomy group exhibited much more laxity. This indicates that sliding the distal attachment of the MCL allows the knee to balance without destabilizing or completely abolishing support of the MCL. This excessive amount of postero-medial laxity could allow for significant instability to occur postoperatively, and if combined with a PCL resection, it is possible that the posterior stabilized peg could disengage from the femoral housing. This view is supported by previous reports of increased medial flexion gaps with sacrifice of the PCL measured in cadaveric knees.

The support mechanism on the medial aspect of the knee with medial epicondylar osteotomy has been explained through dynamic contraction of the adductors on the medial epicondyle. Surgeons should not rely on dynamic support of medial musculature to provide stability to the knee. The normal function of the adductors may not always maintain enough muscle tone to allow complete and constant support of the knee during the healing phase of the epicondyle. One instability episode may be enough to completely stretch and render inadequate the medial side of the knee joint. The previously reported results of the medial epicondylar osteotomy reported a 46% fibrous union of the epicondyle. The authors also reported no significant valgus instability at full extension or 30° flexion, but they did not quantify the clinical examination and did not report stability in flexion. It is possible that these patients could be much more lax in flexion.

When comparing the clinical results of the current series with reported series, the current series had twice as many patients, similar clinical knee scores postoperatively (94.5 compared with 93), and a much higher preoperative varus and flexion contracture deformity than did the epicondylar osteotomy series (6° compared with 12.4° varus and only 23 of 70 knees had flexion contracture greater than 10° compared with all 118 patients in the current series having a flexion contracture greater than or equal to 15°).

No significant intraoperative problems were documented in any of these cases that would have warranted a medial epicondylar osteotomy to allow access to the medial or posterior medial aspect of the knee joint. By first making all bony cuts of the tibia and femur and then removing all osteophytes, all needed ligament releases were performed without additional exposure.

In the current clinical series, half of the knees with significant varus deformity did not require release of the MCL for balancing. In these knees, the removal of osteophytes was enough to balance the medial side of the knee joint. If a medial epicondylar osteotomy is performed for exposure before the medial and posteromedial tibial osteophytes are removed, then the surgeon may be adding more laxity than is necessary to balance the total knee replacement. By hyperflexing the knee with downward pressure on the foot after subperiosteally releasing the ante-ro-medial capsule during the approach, the proximal tibia is exposed and allows for removal of the proximal tibial osteophytes in this region with a rongeur. This maneuver generally works even when a combination of severe fixed deformities of the knee is present.

The posterior capsule was left intact in the knees tested in the laboratory portion of this study, but the clinical review of this technique revealed that the posterior capsule was released in more than half the pa-
tients in the series. This is not surprising because these cadaveric specimens were not arthritically deformed and represented a guideline for how the deformed knee will respond with the structural releases defined. Some authors have published results suggesting that the PCL is involved in the flexion contracture pathology of the knee, and they have recommended their release.\textsuperscript{11,12} Coauthors of cadaveric studies also have reported the importance of the PCL for flexion and extension gap matching and as a secondary valgus supporting structure.\textsuperscript{3,13,14} In our experience, retaining the PCL has not been a problem, as was seen in this reported clinical series in which only one of 118 knees had the PCL released completely and 23 of 118 knees underwent balancing of the PCL as has been described previously.\textsuperscript{14}

Other experimental studies on ligament balancing have confirmed the greater laxity achieved in flexion versus extension with MCL release.\textsuperscript{3,15,16} These studies have reported using a valgus load and a joint distraction load that resulted in similar conclusions. The tensing of multiple posterior structures and the sliding release of the MCL, which leaves intact the periosteal attachment distal to its insertion, is the reasoning behind the differential effects in flexion versus extension, and these are further amplified with the medial epicondylar osteotomy technique.

The current authors acknowledge the inherent weaknesses of using non-deformed cadaveric knee specimens to simulate living tissue with deformity. However, the use of cadaveric specimens to record trends for comparison in investigations of this kind has been well reported within the TKA literature.\textsuperscript{4,12-16} In addition, only one implant design by one manufacturer was used in the study, but the same implant design of appropriate size was used in both the clinical series and the laboratory series.

\textbf{CONCLUSION}

In view of the results of the current study, we do not see the need for extended exposure in this group of patients using a medial epicondylar osteotomy. If a surgeon decides to use a medial epicondylar osteotomy, extreme care should be taken to preserve the PCL and consider the use of a constrained implant to guard the patient against valgus instability in flexion postoperatively.

\textbf{REFERENCES}

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