Review Article

Soft-tissue Balancing During Total Knee Arthroplasty in the Varus Knee

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Abstract

Soft-tissue balancing during total knee arthroplasty is an important step in optimizing the mechanical balance of the knee joint. Soft-tissue contractures that result from varus coronal plane deformity can pose a difficult problem, and the surgeon should have a standard procedure for managing such situations in the operating room. Balance may be assessed intraoperatively with the use of spacer blocks, laminar spreaders, and tensioning devices as well as by placement of trial components. Techniques used to balance the varus knee during primary total knee arthroplasty include femoral component rotation, osteophyte resection, soft-tissue release, and bone resection. Flexion and extension gap balancing is crucial for long-term success and patient satisfaction.

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Proper soft-tissue balancing during total knee arthroplasty (TKA) is paramount to ensure long-term success postoperatively. Even minimal coronal deformity may necessitate some degree of soft-tissue release for balancing. That instability after primary TKA has been reported as one of the major factors for early revision and poor outcomes is another reason surgeons need to understand this topic.[1]

Testing for soft-tissue balancing during TKA was popularized by Freeman et al[2] and Insall et al,[3] who used spacer blocks and laminar spreaders to assess the extension and flexion gaps intraoperatively. For arthritic knees with significant varus or valgus deformity, this is an essential step during TKA to optimize the mechanical stability of the knee replacement. Inadequate soft-tissue release about the knee is usually associated with either instability or recurrence of deformity postoperatively. However, an overzealous release may produce instability on the contracted side of the joint or an increased flexion space, which may lead to knee instability in flexion with a posterior cruciate ligament (PCL)-retaining (ie, cruciate-retaining, or CR) implant or to dislocation of a posterior-stabilized (ie, PCL-substituting, or PS) total knee as a result of exceeding the jump height of the post in flexion.[4]

Many studies have reported on the effects of soft-tissue release in flexion and extension.[5-13] Most of these cadaver studies were performed on knees without deformity. Although these studies provide a useful anatomic map of the effective sequential soft-tissue releases on the flexion and extension gaps, they may not completely simulate what occurs in the operating room.

A logical stepwise approach should be used in the management of varus deformity during primary TKA. The approach we describe is based on anatomic studies, clinical outcomes, and the authors' clinical experience.

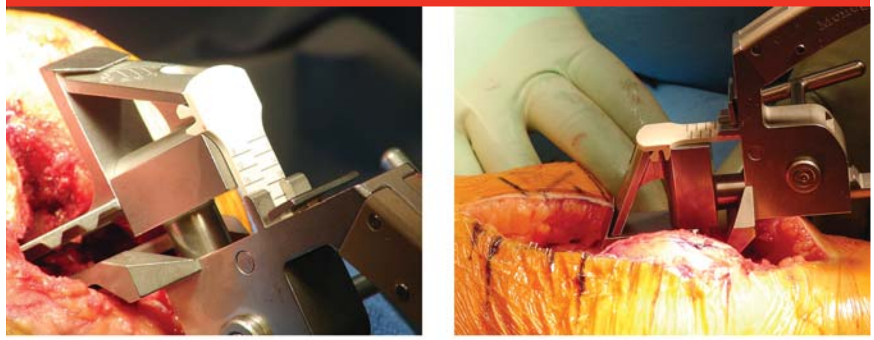
Soft-tissue Release and Gap Balancing

A review of anatomic studies assessing the influence of sequential soft-tissue release on balancing a TKA reveals several essential concepts that every surgeon should understand to best approach flexion and extension gap imbalances intraoperatively.[6,10,11] The critical structures on the medial side of the knee include the superficial medial collateral ligament (SMCL) fibers on the anterior side, and posterior structures such as the posterior oblique ligament (POL) and the semimembranosus fibers that coalesce into the posterior capsule. Release of the anterior structures tends to effectively increase the flexion gap more than the extension gap, whereas release of the more posterior elements tends to affect the extension gap more than the flexion gap. The addition of a PCL release for a PS knee increases the flexion gap.[5]

Intraoperative Assessment of Gap Balancing

Two techniques are used most often for assessing ligament balance intraoperatively. Some surgeons advocate the use of laminar spreaders or tensioning devices[14] (Figure 1). Others assess gap balancing by placing the trial components and then applying varus and valgus stress to the knee. All of the rules presented herein are applicable regardless of method or instrumentation used to assess the gaps.

Figure 1



A **B**

Intraoperative photographs demonstrating the use of a tensioning device in flexion **(A)** and extension **(B)** to assess gap symmetry during total knee arthroplasty.

We recommend that all bone cuts of the femur and tibia be performed first, followed by excision of all osteophytes. All posterior femoral condylar osteophytes should be excised because they can restrict full extension. At this point in the procedure, the flexion and extension gaps can be assessed under a distractive load by use of spacer blocks, laminar spreaders, or tensiometers. Alternatively, the trial prosthetic components can be used as spacer blocks, and varus and valgus stress can be applied in flexion and extension to assess gap balancing. When the medial and lateral joint gaps are not balanced in both flexion and extension, the specific releases should be performed. A comparison cadaver study found equivalent results using a distractive force and the trial component technique.[13]

Some surgeons recommend that the flexion gap dictate rotation of the femoral component. Following soft-tissue balancing, the flexion space is balanced by rotating the femoral component to equalize the filling effect of the femoral component in flexion.[15] However, the surgeon must take care because significant release of the medial or lateral soft-tissue sleeve with release of the PCL to obtain soft-tissue sleeve balancing may result in a larger flexion space on the released side compared with the extension space.[6,10,13] In a varus knee, the presence of a larger medial flexion space following releases may indicate that it may be

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necessary to perform internal rotation of the femoral component to balance the flexion space; however, this technique to balance the flexion gap must be cautiously utilized. The amount of femoral component rotation that the flexion gap may dictate must be compared with traditional landmarks such as the epicondylar axis and AP axis described by Whiteside and Arima.[16] When the flexion space dictates an internally rotated femoral component, then the surgeon should reevaluate this step and compare the suggested rotation with more traditional landmarks. There are significant concerns of patellar maltracking following significant internal rotation of the femoral component.[17,18] When the flexion gap is excessive in flexion in either case or when the jump height of a PS post is in question, it may be necessary to compensate for this instability by increasing the constraint of the implant. This technique is often advocated for mobile-bearing TKA implants to allow gap equalization through femoral bone cuts in flexion in order to avoid imbalance and bearing spin-out in flexion. This technique should be used with caution in the presence of significant deformity that requires substantial soft-tissue releases because these releases may affect the flexion gap more than the extension gap.

Varus Knee Anatomy and Structural Release Techniques

The presence of osteophytes on the medial aspect of the tibial plateau and on the medial femoral condyle can have a significant tightening effect on the structures that make up the medial soft-tissue sleeve. For this reason, all osteophytes should be removed before any soft-tissue release is performed. Removal of the osteophytes that impede on the medial soft-tissue sleeve is often enough to provide a balanced flexion and extension gap in the varus knee.[19] Supporting soft-tissue structures about the knee that are available for release are classified as static (ie, capsular, ligamentous) or dynamic (ie, musculotendinous). On the medial aspect of the knee, the SMCL, POL, and posterior capsule are the static stabilizers, and the pes anserine tendons and the semimembranosus tendon are the dynamic stabilizers.

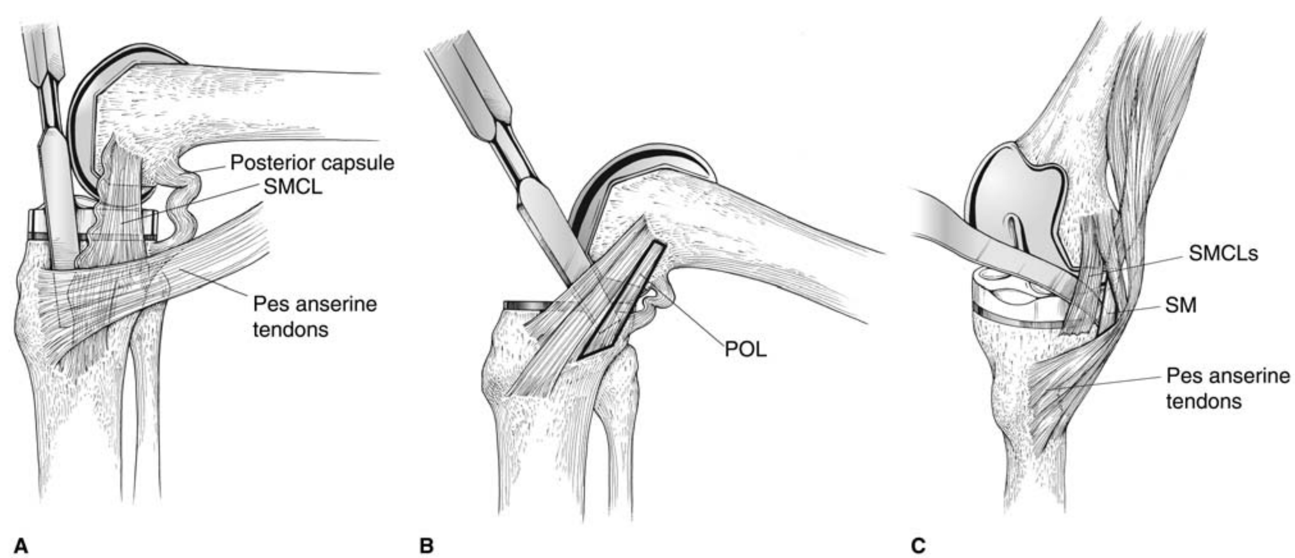
The SMCL has its origin on the medial epicondyle and its tibial insertion on the medial aspect of the upper tibia. A subperiosteal technique is used to release the SMCL off the tibial insertion from just medial to the pes anserine tendon insertion to the medial aspect of the upper tibia. It may be necessary to extend the release 6 to 8 cm past the joint line to obtain an effective release on the entire medial aspect of the proximal tibia when retaining the PCL. However, the surgeon should begin by performing a less extensive release and then reassess the flexion and extension gaps so that the appropriate amount of release can be obtained without causing overcorrection resulting from an excessive amount of release (Figure 2, A). The SMCL structure has been shown to affect both the flexion and the extension gap; however, release of only the anterior portion affects the flexion space more than it does the extension space.[6,10]

Alternatively, division of the SMCL has been described at the level of the joint for management of knees with small varus deformities.[20] In this technique, the contracted portion of the ligament is identified while the medial aspect of the joint is held under distraction with a laminar spreader. The POL and the posterior capsule should not be released when this technique is used because of the possibility of destabilizing the medial soft-tissue sleeve.

The POL fibers of the medial collateral ligament run in an oblique fashion from the upper posterior aspect of the SMCL fibers into the posteromedial aspect of the medial flare of the proximal tibia (Figure 2, B). The insertion of the POL is released in a subperiosteal fashion from the medial-most point of the tibial cut. This release is directed at a 45° angle in the posterior direction. In cadaver studies, release of the POL has been shown to affect mainly the extension space. The POL should be the first structure released when the knee is tight only in extension and not in flexion. Another indication for release of the POL occurs when, after release of the SMCL, the knee remains tight in extension. If the knee remains tight in full extension after release of the POL, then release of the semimembranosus tendon should be considered.[10]

The semimembranosus tendon has a complex attachment to the posteromedial aspect of the tibia, with five described insertion sites. The area in which the tendon blends with the posteromedial aspect of the tibia and posterior capsule is targeted for release. Release of the semimembranosus tendon at this area is usually only necessary in the knee with significant varus coronal deformity or combined varus and flexion contracture deformity. A subperiosteal technique is performed to release the insertion from the posteromedial aspect of the proximal tibia (Figure 2, C). This allows the tibia to be externally rotated and provides easier access to the posteromedial aspect of the tibial resection. Osteophytes in this region should be removed prior to release of the semimembranosus tendon. The posterior nature of its blended insertion with the capsule means that release of the semimembranosus tendon affects the exten-

Figure 2



A, Illustration of the attachment site of the medial soft-tissue structures available for release to achieve gap balancing in the varus knee. **B,** The posterior oblique ligament (POL), a portion of the superficial medial collateral ligament (SMCL), attaches on the posteromedial aspect of the proximal tibia. The more posterior aspect of this structure affects the support it can provide to the knee in full extension; because the structure is more lax in flexion, it has limited effect on the flexion gap. **C,** The semimembranosus tendon (SM) and posterior capsule attach on the proximal tibia.

sion space more than it does the flexion space.

The insertions of the sartorius, gracilis, and semitendinosus muscles appear in order from superior to inferior, just medial to the proximal portion of the anterior crest of the tibia. The pes tendons usually are not the first line of release for balancing the medial aspect of the joint, and they are typically released only in the presence of significant varus deformity. These tendons can be released off the proximal tibia, and their release has been shown to affect extension more than flexion.[6]

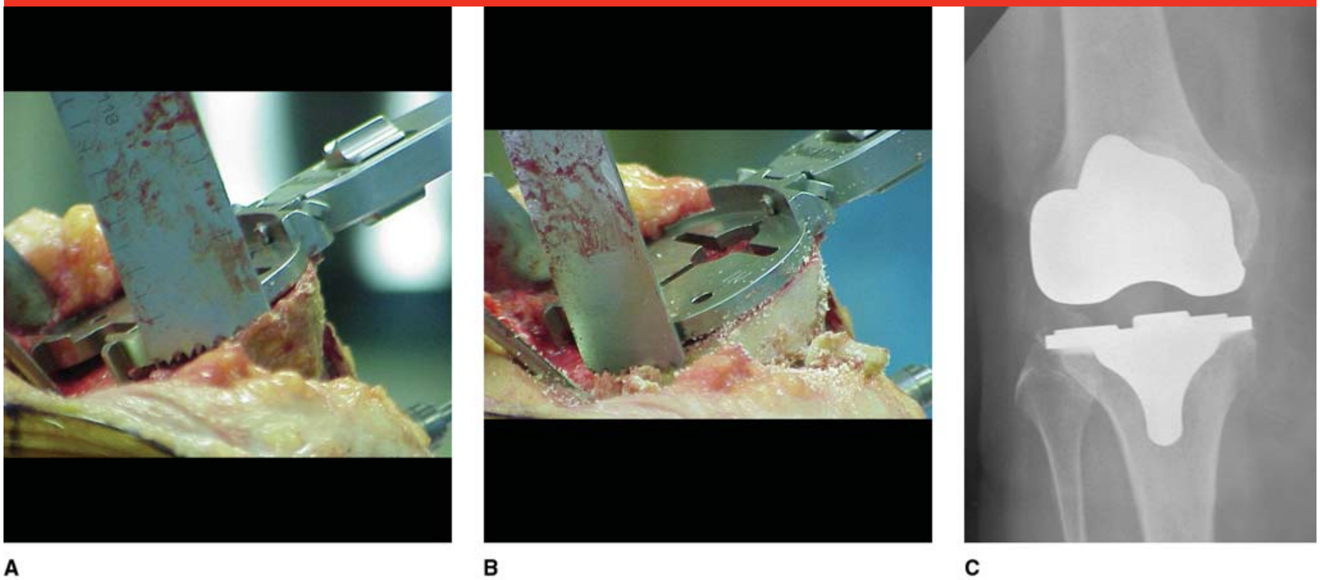
Osteotomy of the medial epicondyle has also been reported to aid in balancing and providing exposure of the varus knee with flexion contraction.[21] This technique may be useful in the knee with severe combined varus and flexion contracture deformity and may be worthy of consideration when managing the severely contracted varus knee.

Another option for the knee with more severe varus deformity involves resection of the bone along the medial tibial plateau, with downsizing and relative lateralization of the tibial baseplate.[22,23] This technique provides soft-tissue balancing in the varus knee without affecting the more distal insertion of the SMCL on the tibia. The technique involves downsizing of the tibial tray when acceptable bone quality permits, as well as lateralization of the tray on the proximal tibial (Figure 3). Excess proximal tibial bone around the periphery of the medial aspect of the tibial tray is removed to allow greater excursion of the medial soft-tissue sleeve while maintaining stability of the attachments distally to the tibia. This may allow for preservation of a more normal soft-tissue attachment distal to the joint line with effective balancing of the soft-tissue sleeve. The final effect is one of releasing a medial contracted soft-tissue sleeve along with relative medialization of the tibial tubercle, which may enhance patellar tracking.

The presence of severe varus deformity signals the possibility of significant loss of soft-tissue support on the lateral or convex side of the knee. In these cases, release of the aforementioned soft-tissue structures may not resolve the gap imbalance because of the presence of redundant soft-tissue support on the lateral side of the knee. If, after complete release of medial-sided structures, imbalance persists and the medial gap is tight, the surgeon should consider advancing the lateral collateral ligament (LCL) to correct the imbalance. This can be accomplished on the fibular side of the joint by osteotomizing the proximal fibula and advancing it distally to tighten the LCL.

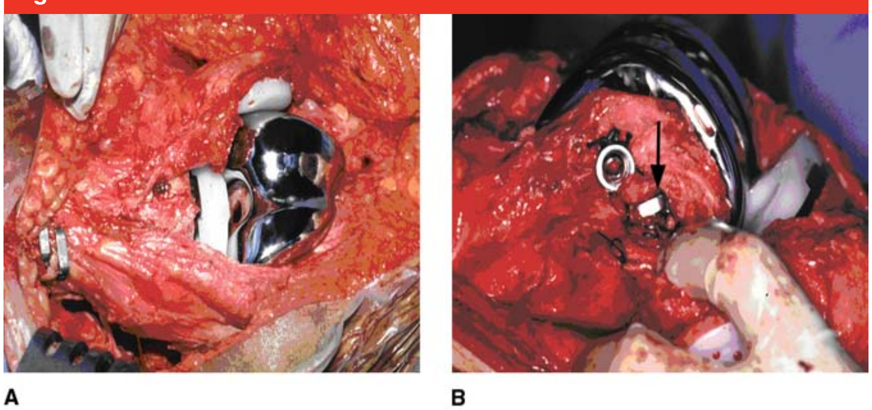
The proximal fibular segment is first predrilled along the intramedullary canal to prepare the site for fixation of the proximal segment and the insertion of the LCL. Care must be taken not to injure the peroneal nerve as it courses about the neck of

Figure 3



A and B, Intraoperative photographs demonstrating resection of the medial aspect of the tibia with slight undersizing of the tibial component. A trial component is in place. This approach elongates the medial soft-tissue sleeve and increases the size of the medial joint gap to enable effective release. **C,** Postoperative AP radiograph demonstrating effective lateralization of the tibial tray, which also serves to medialize the tibial tubercle to facilitate better patellar tracking.

Figure 4



A, Intraoperative photograph demonstrating distal advancement of the medial collateral ligament, which can be utilized if a complete release of the superficial medial collateral ligament causes the medial gap to be too large. Soft-tissue staples were used to fix the ligament at the tibial insertion at the appropriate length to balance the gap. **B,** If the medial gap is too tight even after complete release of the medial structures, the LCL can be advanced to create a lateral gap of a size equivalent to that on the medial side. In this photograph, the LCL is advanced proximally and reattached to the lateral epicondyle at its anatomic origin. A running locking-type stitch is utilized to secure the LCL over a screw proximal to the epicondyle (arrow), and the newly created shorter length of the LCL is attached at the lateral epicondyle using a soft-tissue staple.

the fibula when the transverse osteotomy is performed. With trial components in place, the proximal fibular segment with the insertion of the LCL is then tightened until the ligament is seen to be supporting the lateral side of the joint. The excess overlapping bone is marked and removed. The fibular head is fixed in place with an intramedullary screw and washer.

Alternatively, the origin of the lateral epicondyle can be advanced proximally to tighten the LCL and balance the joint gap. A running locking stitch (ie, Krackow) using nonresorbable suture is created, and the origin is pulled tight across the joint line at the epicondyle. The ligament is fixed at the epicondyle with a staple (Figure 4) so as not to change the kinematics of the LCL. The running locking stitch is then tied over a screw proximally. This repair must be protected from varus stress with a hinged brace for 6 to 8 weeks postoperatively.[24]

Occasionally, an overcorrection of the medial gap may occur after release of several structures in an attempt to balance the knee. Provided that the medial sleeve is still supportive, the surgeon may consider concomitant release of lateral structures to equalize the gap or utilize a soft-tissue staple to reattach the SMCL at the appropriate length to balance the gap. In this case, the surgeon also should assess for iatrogenic SMCL laceration. If this has occurred, then augmentation of the ligament with the semitendinosus can be undertaken, or primary repair of the SMCL may be considered.

In any of these cases in which the SMCL has been repaired or augmented, a postoperative hinged brace allowing range of motion should be used to protect the repair for 6 to 8 weeks. Weight bearing is allowed as tolerated, but activity that creates a coronal plane moment must be avoided (eg, side-to-side motion, abduction and adduction exercises).

Posterior Cruciate Ligament Balancing

The PCL is both a posterior and a medial structure; thus, it may be contracted in a varus-deformed lower extremity. When the PCL is retained, it must be assessed and balanced. If the PCL is contracted in a varus knee, then the femoral condyle will typically articulate at 90° of flexion with the posterior one third of the tibial component insert. A tight PCL may also cause lift-off of the tibial trial insert in flexion.

Three release techniques are available to balance the knee in the presence of a tight and contracted PCL. In the first technique, the origin of the PCL is sharply released from the intercondylar notch of the medial femoral condyle. The second technique involves subperiosteal release of the PCL from the posterior aspect of the tibia. The third technique involves removing from the posterior tibia a V-shaped piece of bone that incorporates the entire insertion of the PCL. Care must be taken not to disrupt the capsular attachment so as to preserve some inherent soft-tissue support while allowing the PCL bony insertion to heal in an elongated state. If the PCL is involved in the deformity and the femoral condyles do not articulate in the posterior half of the tibial insert at 90° of flexion following release, then conversion to a PS implant or use of a high-lipped anterior tibia polyethylene liner is necessary to prevent posterior sag of the knee postoperatively.

Posterior Cruciate Ligament Substitution and the Flexion Gap

The PCL supports the flexion gap. Thus, release of the PCL results in a flexion gap that is larger than the extension gap. Therefore, it is recommended that the distal femoral bone resection be increased to aid in equalizing the gap. When complete medial release and PCL sacrifice are performed, the medial flexion gap may be excessive compared with the extension gap, and the jump height of a PS post may be exceeded. The tibia is usually cut with no posterior slope to reduce the risk of this complication. The surgeon must be diligent in assessing the flexion gap in these cases. When the jump height of a standard PS post is exceeded, use of a constrained condylar component may be necessary.

The PCL is also a significant secondary stabilizer to motion in the coronal plane. For this reason, care should be taken to assess balance after small amounts of structural release. Moving to a complete medial release may introduce instability, especially in flexion, if one is not careful. When sacrificing the PCL, less release typically offers better balance. When preserving the PCL, a greater amount of release is typically necessary because of the support provided by the PCL in the coronal plane.

Management of Combined Flexion Contracture and Varus Deformity

Whether a PS or a CR TKA is performed, most flexion contracture deformities can be corrected with soft-tissue release alone.[8,21] More distal femoral bone resection may be necessary in the presence of a significant flexion contracture and when extensive soft-tissue releases fail to reproduce full extension of the knee intraoperatively. Whether a PS or CR TKA surgical approach is used, increasing the amount of distal femoral resection increases the extension space while preserving the flexion gap. However, although full extension can be obtained in the presence of severe flexion contracture, problems in mid flexion can occur when the distal femoral resection is increased. Significantly raising the joint line can lead to laxity of the collateral ligaments in mid flexion, which presents a considerable stability problem. The finding of mid flexion instability after the distal femoral resection level is increased should prompt the surgeon to consider increasing the constraint of the implant.

In managing flexion contracture in a varus knee, the surgeon should make sure that the distal femoral resection is not measured off a distal femoral osteophyte because doing so can result in a smaller distal femoral resection, thereby compounding the problem. Once the soft-tissue sleeve has been released and the medial and lateral gaps have been made equal, then full extension of the knee likely will be possible. In a CR TKA, the surgeon needs to make sure that the PCL is not contributing to the coronal deformity. Such contribution to

Figure 5

Flexion \ Full extension	Medial compartment too tight	Medial compartment balanced
Medial compartment too tight	1. Release the SMCL or downsize the tibial baseplate and resect the medial bone, then recheck balancing 2. Release the POL and recheck balancing 3. Release the SM and recheck balancing 4. Check the PCL and recheck balancing 5. Release the posterior capsule and recheck balancing 6. Release the pes anserine tendons and recheck balancing 7. If still tight, consider LCL advancement	1. Release the anterior SMCL and recheck balancing 2. Release the full SMCL and recheck balancing 3. Check the PCL before each release listed above
Medial compartment balanced	1. Release the POL and recheck balancing 2. Release the SMCL and recheck balancing 3. Release the SM/posterior capsule and recheck balancing	Flexion and extension gap balance achieved

Four-by-four matrix delineating structures to consider for release when attempting to achieve soft-tissue balancing in flexion and extension in the varus knee. After each release, the knee is rechecked for balancing in flexion and extension. If balancing in either position has been achieved, the structures in the corresponding cell are considered for release. In a posterior cruciate ligament (PCL)-sacrificing posterior-stabilized total knee arthroplasty, an increase in the flexion gap caused by loss of PCL support can be addressed by making a tibial bone cut with no posterior slope and by increasing the distal femoral cut by 2 mm (up to 4 mm). If an unstable increase in the flexion gap occurs with loss of the PCL or following releases with a cruciate-retaining technique, the surgeon should consider conversion to a constrained condylar implant. LCL = lateral collateral ligament, POL = posterior oblique ligament, SM = semimembranosus tendon, SMCL = superficial medial collateral ligament

deformity can occur because contraction of this medial structure causes imbalance between the medial and lateral gap. For persistent medial and lateral gap imbalance in flexion following release of the PCL, release of the posterior capsule can aid in equalizing the gap and can help correct the flexion contracture by increasing the medial gap in full extension as well.

The posterior capsule should be released when flexion contracture (ie, smaller extension gap) persists after soft-tissue balancing has equalized the medial and lateral gaps. The capsule must be released subperiosteally from the femur. Overzealous release may lead to violation or avulsion of the superior geniculate arteries, and it is very difficult to coagulate the artery in this area. If the flexion contracture persists after release of the posterior capsule, then more bone should be taken off the distal femur to correct the flexion contracture. The surgeon should resist the urge to release the PCL in this setting if it is not involved in the varus deformity because the PCL does not contribute to the flexion contracture deformity. It has been shown experimentally as well as in reported clinical series that the PCL affects the flexion gap much more than the extension gap.[5] Clinical data have shown that in the presence of significant flexion contracture, release of the PCL is not necessary to obtain full extension.[8,19]

An increase in the disparity between the flexion and extension gaps may occur with PS TKA. In such cases, care should be taken to make sure the jump height of the tibial post is not exceeded. Use of a larger femoral component with anterior referencing can also aid in ensuring that the flexion gap is not excessive in this scenario.

Authors' Preferred Technique

Once all bone cuts have been made and all osteophytes excised, the flexion and extension gaps are assessed using trial components or a distraction method. The possible scenarios for medial flexion and extension gaps in the varus knee, as well as techniques to correct them, are presented graphically in Figure 5. When the medial side of the joint is tight in flexion and extension, the SMCL is released subperiosteally from the medial aspect of the tibia. When the knee continues to be tight, the release moves posteriorly about the medial aspect of the tibia to the POL and then the semimembranosus tendon, using similar techniques and checking for soft-tissue balance after each step. When performing a CR TKA, the PCL must be checked before each release to make sure that it is not contributing to the coronal deformity. If necessary, the PCL should be balanced. The posterior capsule and the pes anserine tendons are evaluated when imbalance persists. When release of all structures fails to balance the knee, LCL advancement is considered.

Tightness medially with the knee in flexion only should alert the surgeon to first consider release of the anterior aspect of the SMCL. Conversely, if the knee is tight only in extension on the medial side, the POL and semimembranosus or medial posterior capsule should be released; however, persistent flexion contracture even after the medial gap has been balanced may warrant increasing the distal femoral resection. If the distal femoral cut is increased, the joint line should not be moved more than 4 mm in order to prevent mid flexion instability.

For the PS TKA, the surgeon needs to compensate for the increased flexion space associated with release of the PCL.[5] This can be addressed by increasing the distal femoral resection by 2 mm and then making sure that there is no posterior slope in the proximal tibial resection. This will slightly increase the extension gap while maintaining the flexion gap. All osteophytes should be removed before assessing gap balancing. Regardless of the approach used to assess balancing, the approach is similar to that described for CR TKA. However, with a PS knee, the surgeon must be cognizant whether complete release on the medial knee with the addition of the loss of support in flexion of the PCL results in the flexion gap being greater than the extension gap on the medial side. Because a PS post does not lend stability in the coronal plane with the knee in flexion, the surgeon must make sure that the jump height is not exceeded in flexion. If this is of concern, then it may be necessary to increase the amount of constraint on a constrained condylar implant. Similarly, if complete medial release of structures cannot equalize the medial gap, LCL advancement should be considered.

Discussion

The need for balancing the soft-tissue sleeve of the knee to create rectangular gaps is well recognized as a critical step in TKA. However, most published reports of clinical outcomes following TKA in the varus osteoarthritic knee have addressed implant longevity and/or alignment. The surgeon should use these studies as a guide regarding the success of the techniques discussed here.

Whiteside et al[10] reported on the functional balancing of the medial soft-tissue sleeve in 76 patients (82 knees) with varus deformity treated with primary TKA. The protocol for soft-tissue release was substantiated by a cadaver study showing the effects of release of the anterior SMCL and the POL on knee stability in flexion and extension. After osteophyte excision, 62 knees needed further attention to balance the medial soft-tissue sleeve. Balance was achieved in 50.0% of these knees following release of the anterior SMCL to correct tightness on the medial side in flexion only, in 35.5% in which the POL was released to correct medial tightness in extension only, and in 14.5% in which both the SMCL and POL were released to correct medial tightness through the flexion arc. In 27% of knees, balancing of the PCL was required to manage excessive rollback and lift-off of the trial tibial insert in flexion.

Mullaji et al[23] reported the outcomes of severe varus deformity (preoperative tibiofemoral angle >20°) in 173 knees (117 patients). The technique consisted of a combination of medial soft-tissue releases with the use of PS implants and cruciate excision in all cases. The posteromedial capsule and the semimembranosus tendon were released to achieve soft-tissue balancing. Release of the semimembranosus tendon was also helpful in aiding exposure. The tibial component was downsized when balancing was not obtained using soft-tissue releases, and successive resection of posteromedial and medial tibial bone was performed until the gaps were balanced. Any knee that was not balanced following these procedures was managed with further release of the SMCL and pes anserine tendons. At an average follow-up of 2.6 years, the mean Knee Society Score was 91.1, up from 22.8 preoperatively. The function score had improved from a mean of 22.8 preoperatively to 72.1 postoperatively.

Dixon et al[22] reported on a series of 12 knees in 10 patients with a mean varus deformity of 24°. The PCL was retained, the tibial base plate was downsized by one size and shifted laterally, and the medial bone of the tibia was excised. All 12 knees were balanced using this technique, and no further releases were necessary. The tibiofemoral angle was corrected to an average of 4° of valgus. The mean Knee Society score increased from 24 preoperatively to 94 at a mean follow-up of 42 months. The function scores increased from a mean of 34 preoperatively to 85 postoperatively.

Teeny et al[25] compared the outcomes of surgery on 27 knees (20 patients) with ≥20° of varus deformity preoperatively with 40 TKAs (31 patients) with <5° of varus or valgus deformity preoperatively. The authors used the SMCL, the posteromedial capsule (a portion of the semimembranosus tendon), and the pes tendon insertion to obtain rectangular flexion and extension gaps. Fewer than half of the patients required PCL balancing to address imbalance in flexion. Longer surgical times and more variable results were reported in patients with severe varus deformity than in those without deformity. The authors also reported residual varus deformity on the tibia after TKA in the severe deformity group and knee scores that were more variable than those in the nondeformity group.

Summary

Multiple techniques are available for use in addressing the soft-tissue imbalance that may arise in the varus knee during primary TKA. Knee flexion and extension gaps following bone cuts and osteophyte resection usually can be balanced by following a logical series of steps based on the individual factors involved. Care should be taken not to leave the joint gaps unbalanced or to leave the patient with residual flexion contracture or recurvatum deformity. Either of these conditions can significantly affect the longevity of the knee replacement and the patient's perceived outcome of the surgery and may result in delayed soft-tissue imbalances.

References

Evidence-based Medicine: Levels of evidence are listed in the table of contents. In this article, no level I or level II studies are cited. References 15 and 25 are level III studies. Level IV studies include references 1, 8, 10, 11, 14, 19, and 21-23. Level V studies include references 2-4, 16, 20, and 24.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

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