Chapter 12.3

The Unstable Knee

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Definition:

Ligamentous stability in total knee arthroplasty can be defined by accurate balancing of the ligaments in relation to the intrinsic stability offered by the mechanical constraint of the prosthetic implant. The extrinsic ligamentous stability may be highly essential with an unconstrained bicruciate preserving LCS implant or only moderately essential in a VVC type of constrained insert device, as compared to the low requirement in the hinge total knee implant. The other important element of stability is the function of muscles about the knee. Function of the extensor mechanism is critical to total knee performance, while the hamstrings are moderately important in stability but must be present for function of gait. Instability in total knee arthroplasty can be defined as ligamentous or soft tissue laxity resulting in symptomatic discomfort and the feeling of buckling along with clinical findings of swelling and detectable gap opening on stress. It is possible for knee dislocation to occur from extensor mechanism insufficiency where the femur may dislocate anteriorly on the tibia. This problem has resulted from femoral nerve palsy or patellar tendon disruption. However, we will confine our discussion only to instability resulting from imbalance of the femorotibial ligaments. With the LCS system, a typical clinical finding has been bearing dislocation or spinout, which will be discussed in other chapters. With fixed bearing prostheses, such dislocation is not likely, and the patient more likely experiences a problematic poor result. Recent studies have shown that the percentage of revisions done for ligament instability can be as high a 39%. This is disturbing as the complication is virtually preventable in every case, and only in the most extenuating circumstances should the outcome be purely attributed to surgeon's error.

Etiology:

Figure 1 and 2

The primary cause of ligamentous instability in total knee arthroplasty is extension/flexion imbalance. Typically, the problem is found very early after primary surgery and reflects poor balancing of ligaments such as the posterlateral capsule in a valgus knee, and will compounded by abnormal bone cuts that do not balance the knee prosthesis in extension and flexion. Experts have mistakenly recommended that mild laxity is tolerated or even beneficial to improving postoperative range of motion. The facts would indicate that moderate postoperative laxity will only worsen with time as opposed to excellent well-balanced ligament tensioning. LCS surgeons have learned that the toleration of the unconstrained and dislocatable bearings for ligament imbalance is relatively low. The advantage of the tibia-cut-first flexion space balancing is discussed well elsewhere in this book, but we will only reiterate this inviolate concept. Surgeons who choose an anatomical fixed bone resection, given the disparate anatomy of the human knee in normal and diseased cases, will only learn the hard way.

Early instability with the LCS will generally lead to a bearing dislocation or spinout problem. With fixed bearing total knees, the patients typically experiences an early "poor" result. Late instability is a more insidious problem and is something more likely to be seen with the LCS. As we have stated, from the work of Hamelynck, if ligaments are closely balanced at the outset, late ligament stretching is unlikely. On the other hand, if the ligaments are poorly balanced, the condition is progressive and will gradually worsen over time. The other important consideration is the instability that results over the long term from implant subsidence and rarely wear, which in effect makes the knee more unstable.

Late rupture of the posterior cruciate ligament may occur if tibial resection exceeds 8 millimeters, weakening the cruciate insertion.[6,7] We have witnessed this problem with the cruciate retaining meniscal bearing knees and more recently the AP Glide prosthesis which will fail if the posterior cruciate gives way. There is an American contingent, who actually believes in partially resecting or releasing the posterior cruciate from proximal tibia as a means of creating balance of the knee in flexion. With the mobile bearing devices, this is inviting disaster. Surgeon experience with the AP Glide would suggest that loss of the posterior cruciate ligament is tantamount to a revision for chronic instability.

Another concern is excessive joint line elevation as this may reflect a large flexion gap and difficulty gaining full extension.[8,9] The surgeon may leave the knee lax in flexion to avoid overresecting distally. Conversely, if the distal femur is overresected, the surgeon will then insert a larger insert to balance in extension. If a smaller insert is used, it may allow adequate knee flexion, but leave the knee unstable in extension and mid-flexion. To avoid raising the joint line, we would advise trying to create the smallest flexion space possible, and later in this chapter such ideas are proposed. For the LCS primary technique, this usually means moving the anterior/posterior cutting block a notch or two dorsally, or even upsizing the prosthesis whenever possible. The end result is that the flexion space is reduced, the extension space becomes less, and ultimately the joint line is raised less.

With the LCS system, surgeons have learned that careful balancing of the gaps is critical to the performance of the total knee and for the avoidance of clinical instability. Our kinematic studies have shown that good clinical function demonstrates small amounts of joint space opening, on the order of three to four millimeters throughout the range of motion in both the medial and lateral compartments, with or without posterior cruciate preservation. In general, greater than 15 millimeters of anterior/posterior laxity, 10 to 15 millimeters of varus/valgus laxity in extension, and 15 to 20 millimeters of laxity in 90º flexion can be called clinical instability.

Ligament Balancing Problem:

Most standard posterior cruciate retaining surgical techniques use anatomical bone resections based on predetermined landmarks. Examples include the Whiteside intercondylar line, the posterior condyle reference with a 3° to 5° external femoral rotation or transepicondylar line. Stiehl, et.al. have shown that the transepicondylar axis clearly matches the knee flexion axis and is nearly perpendicular to the mechanical axis.[10] However the transepicondylar axis may be difficult to define in primary knee arthroplasty. If the anterior/posterior distal femoral cuts are inaccurate in terms of ligamentous balance, it is difficult to perform subsequent releases to achieve matching flexion/extension balance. Krakow, et.al. has shown that the majority of ligaments released can have indepent affects on the flexion and extension gaps.[1,2,3,4,5] Release of the medial and lateral capsular ligaments, lateral collateral, popliteus,and superficial medial collateral ligaments will affect both the flexion and extension gaps. Release of the pes tendons, iliotibial tract, medial and lateral gastrocnemius, semitendinosus, and biceps tendons affect balance in extension. Release of the anterior and posterior cruciate ligaments increase the flexion gap roughly 50% more than the extension gap. The problem is more difficult if the posterior cruciate ligament is spared as the options for achieving perfect flexion/gap balance become very limited indeed.

Another issue is the effect of extraarticular deformites. Should the surgeon attempt to balance the deformity through the joint, over resection of ligaments may occur with the potential of instability. Similiarly if severe deformity, either in the coronal plane or with flexion contracture be addressed incorrectly, the surgeon can easily leave the knee unbalanced. With the multitude of complexities balancing ligaments, the LCS approach simplifies the problems by using the bone cuts to balance the ligaments instead of vice versa.

Clinical Findings:

1. History:

Flexion instability is frequently seen in poorly balanced posterior cruciate retaining fixed bearing total knee arthroplasty. Insidious pain and swelling are the hallmarks of the problem and reflect both instability and polyethylene wear. Typically, there is pain and tenderness anteriorly. Instability can be gross to the extent that the knee is described as „slopy“. Patients are particularly uncomfortable walking down stairs. Symptoms can be disabling with a strong sense that the knee will buckle or give way. Some patients are so afflicted that they are comfortable placing weight in near extension using crutches or a walker for balance.

Patients will become aware of chronic effusion and swelling. Anterior knee pain is noted and this reflects strain on the anterior tissues due to flexion instability and abnormal anterior femoral sliding in flexion. There may be a visible posterior sag, typical of posterior cruciate ligament laxity or absence. Wasliewski, et.al. has described the quadriceps active test, where contraction of the quadriceps muscle with the knee in flexion causes the proximal tibia to visibly be thrust forward or anterior.[11] In full extension, there may be anterior tibial translation to the extent that the tibia appears to be more forward than normal. The patient may relate that there was no symptom free interval following surgery. Physical therapy and bracing are usually of little benefit. The surgeon may have attempted a tibial insert exchange but this may be of little value if there is gross imbalance. Finally, the history of a postoperative knee dislocation is the hallmark of an unstable total knee arthroplasty.

2. Physical Findings

Figure 3,4,5

The patient will exhibit significant tenderness over the hamstring tendons and insertions, such as the pes, biceps, and semitendinosus tendons. The reason for this is the muscle overactivity that is naturally occuring to deal with the inherent instability. As noted above, greater than 15 millimeters of anterior/posterior laxity, 10 to 15 millimeters of varus/valgus laxity in extension, and 15 to 20 millimeters of laxity in 90º flexion can be called clinical instability. The authors have found an easy test is to place the patient in the sitting position with the leg hanging off the edge of the table. When completely relaxed, the surgeon grabs the distal femoral condyles and then attempts to rock the tibia back and forth. With some practice, this will show amazingly well the amount of laxity in flexion. Standard radiographic studies are usually „normal“ but traction radiographs centered over the joint line with 70° may be illustrative. Aspiration is usually negative for bacterial growth as these cases are typically not infected, but there may be polyethylene wear debris on microscopic evaluation.

3. Detailed Analysis of Balancing Error

For the surgeon to understand the problems, he must go back and review the potential issues that were encountered at the time of surgery. The possibilities include good overall alignment and good ligaments, malalignment and good ligaments, and good alignment with poor ligaments. In the first case, radiographs are usually unrevealing and the surgeon must rely on the above clinical findings. In the second case, component malposition can be seen on radiographs, either from insertional error or late subsidence. In the last case, the clinical condition such as rheumatoid arthritis or polio is the culprit resulting in markedly weakened or atrophic ligaments.

Perhaps the easiest problem to understand is when technique was generally correct with good alignment and reasonable ligament balancing but postoperative instability results. With the LCS system, the most logical explanation is an error in the bone cuts or implant sizing. As the tibia must be cut in the perfect coronal position with the knee in extension, if the tibial cut is internally rotated, imbalance results with tibial varum. The reason for this is that the normal LCS tibial cut is in 7° of posterior tibial slope, and internal rotation of this cut will result in varus tibial component positioning. If the anterior/posterior flexion cut is internally or externally rotated abnormally from exact tension, imbalance results. If the patient is obese and the leg falls into abduction, the heavy weight of the leg may cause the cutting block to externally rotate on the distal femur. Another common cause is overresection of ligaments in severe varus or valgus knees. As the medial or lateral collateral ligaments are released, the gaps increase but as there are more components stabilizing the extension gap, a relative over-release results in flexion. Surgeons anticipate this in the severe valgus knee but not always in the varus knee. Some of the most difficult instabilities we have seen resulted with over resection on the medial side. The knee is not as tolerant of this instability because of the natural knee valgus alignement, and conversely, a minor lateral joint laxity may be better tolerated. We would advise the surgeon to go very cautiously with these releases, titrating and testing the release, but always trying to preserve some inherent stability in the flexion space.

With posterior cruciate balancing the ultimate outcome of the case rests with the balance of the ligaments in flexion. If tensioning is “too tight”, the tibia will sublux forward and stay forward throughout the range of motion. These are the knees that develop chronic stiffness and often poor flexion. If the tensioning is “too loose”, the femur will slide forward on the tibia with increasing flexion, leading to the above findings of clinical instability. We believe that most total knees, especially mobile bearings like the LCS, must have adequate balance in flexion, while a bit of laxity in extension on the lateral side of the joint is more tolerated.

Treatment:

General Considerations:

For the LCS system, ligamentous instability is usually heralded by bearing dislocation or spinout. These issues are covered in above chapters. In general, the surgeon may have been close with balancing the gaps, but through trauma, late instability, or other issues, a problem has arisen. As has been shown by many surgeons, these problems can be resolved by simple bearing exchange. For example, if wear has caused late failure of a meniscal bearing implant, new and thicker bearings usually suffice. In the case of the AP Glide, if there is late posterior cruciate instability causing increased laxity, this can be resolved by a thicker, and more constrained rotating platform implant in most instances.
In an elderly patient who may be high risk for complex surgery, one may consider a period of immobilization of six to eight weeks with the knee held in extension. This may provide enough scarring to prevent gross dislocation, especially if the laxity is on the lateral side of the joint in extension.

In fixed bearing total knee implants, establishing the correct flexion/extension gap balance has not been done correctly and the problem is more difficult. A simple tibial modular insert exchange will not suffice and a revision is generally required. If the tibial base plate fixation and position is satisfactory, the surgeon may consider revising only the tibial insert and the femoral component. As a posterior stabilized femoral implant is typically needed, the surgeon must be comfortable the type of implant utilized and the ability to use the conversion revision implant of that particular manufacturer.

In general, at the time of surgery, careful flexion/extension gap balance is the focus of the technique. Tight balancing of 2 to 3 millimeters in both flexion and extension is the desired goal. A minor flexion contracture of up to 10º is a good idea as most of these will stretch out over the first 12 months after surgery. Finally, modular revision options as will be shown, are critical to this exercise.

Surgical Tactics:

Extension Rebalancing:

For the experienced LCS surgeon, the recommended technique of revision for flexion instability follows identical to the LCS technique in terms of the steps with posterior cruciate resection and the addition of modular solutions for the encountered problems. The first step is to gain correct balance in full extension. If instability is on the lateral side of the joint, the mistake may have been inadequate medial release in the case of severe varus deformity. This should focus on ligaments that affect primarily extension such as the superficial medial collateral ligament. If the superficial medial collateral ligament is released, it must be as a continuous subperiosteal sleeve not to loose any continuity. Then the secondary medial stabilisers in extension should be addressed including the posterior medial corner, the posterior capsule and rarely the semitendinosus insertions and even more rarely the pes insertions. One must preserve something on the medial side to prevent gross medial laxity, and this would be a careful titration of release leaving some of the posterior medial capsular ligament which will provide some stability in flexion. Similiarly, on the lateral side of the joint with tight valgus deformity, the tendency is to release the iliotibial tract, the lateral capsular structures, and finally release the lateral collateral ligament from the lateral epicondyle. Something must be left on the lateral side to prevent gross opening in flexion, and this should be either the popliteus tendon or the posterior lateral capsular structures. Another option the authors have used is to release the lateral collateral orgin and popliteus as a single flake of bone from the lateral epicondyle and then advance these structures distally and anteriorly, thusly giving both release in extension and providing some stability of the knee in flexion. The extension gap must be established before one goes on to the next step, because most LCS users know, once you cut the posterior condyles, you can't rebalance the knee easily in extension.

Tibia Cut First:

As described by Insall, the most logical method for obtaining correct balancing is to use the tibia cut first method. This preferentializes establishing the flexion gap which is the primary problem with the unstable total knee. As Stiehl has shown with the tibial axis rotation method of determing the distal bone cuts, a perpendicular tibial cut will anatomically align with the transepicondylar axis in the normal knee.[10] External alignment jigs may be used, but many revision systems utilize an intramedullary alignment for the tibia in the revision setting and there is no preference. A definite problem with intramedullary rods on the tibial side is the eccentricity both in position and aligment that they may find to the mechanical axis. Systems that allow offset of the tibial base plate may be desireable in this regard.

Flexion Block Method

For the LCS user, the horseshoe spacer is the „brilliant" instrument that allows tension of the flexion gap for routine anterior/posterior condylar resection. Depending on availability modular revision options either with the LCS Revision system or a fixed bearing revision system, a full complement of wedges, builds, modular stems, etc is needed. Two problems are encountered in placing the flexion block. First, the intramedullary canal may be a big „hole" not allowing placement of a firm intramedullary rod. Some systems allow placing graduated larger stem trials into the canal for stabilizing the distal femoral cutting and anterior/posterior cutting blocks. The second problem here is that this stem will tend to drift anteriorly as the stem wants to follow the natural bow of the distal femur. The PFC Sigma Modular Revision system solves this by providing a two millimeter offset of the distal stem in the dorsal direction. If all else fails, an option is to pin the anterior/posterior cutting block on one side in what you think is correct and then place tension on the opposite of the block and then pin that in place. The final goal is assessment of the flexion space and one must have a rectangular flexion space in terms of ligment balance using the flexion spacing blocks.

Figure 6,7

Once the flexion space femoral rotation is established, two additional problems arise. The first is what to do with a poorly placed prior cut, for example if the surgeon cut the distal femur in internal rotation. In that case, the surgeon will obviously need a build on the lateral posterior femoral condyle. Contemporary flexion block jigs will allow you to cut to the defect of the condyle which allows you identify the bone loss and simply supplement with a posterior condylar build. The second problem and perhaps the most significant one of this whole discussion is what to do with an „extra large“ flexion space. One of the authors, JBS has experienced a flexion gap that required 54 millimeters of material to fill the flexion space in unusual case. The following ways have been used to deal with a big flexion space. First is to try to position the axis of the femoral stem axis as far posterior as possible. As noted with the PFC Sigma, this can be done by using a 2 millimeter offset bolt. The second thing to do is to upsize the femoral component giving a greater anterior posterior diameter. This can add several millimeters, especially if the device is placed more dorsally. The final approach is to add posterior condylar builds which not only will provide stability for better fixation, but will push the implant dorsally. Correction of the space orientation can be differentially detemined by adding different thickness of builds to the medial or lateral side.

Extension Space Determination

The last step is to take the knee into extension to determine the extension balance and create the extension gap. If done correctly, this should already be perfectly balanced and now only requires tensioning. Depending on the dimension of the flexion space, the extension space will be determined by either resecting more bone or by adding builds to the distal femoral condyle to push the joint line down. In general the joint line should be low enough to avoid patellar impingment of the tibial insert in deep flexion. This is why efforts to close the flexion gap are so important. At this point of the procedure, if there is a minor amount of extension laxity of 5 to 7 millimeters on the lateral side of the joint, the surgeon may choose a more constrained tibial post option (TC3) to prevent dislocation but any laxity should be avoided if possible. The authors have virtually no experience with collateral ligament advancement techniques for ligament instability and would not recommend them at this time. As noted above, a minor flexion contracture up to 10º limiting full extension may be a good idea, especially in the patient with hyperlax soft tissues. With posterior cruciate resection, this usually stretches out in 12 months.

Postoperative Managment

If adequate ligament balancing has been, these revisions may be treated like any postoperative total knee with early range of motion and gait training. For this reason, ligament advancement methods that require special bracing seem impractical. There may be certain restrictions required if a tibial tubercle osteotomy or quads snip are done.

Conclusion:

In the authors' experience, instability is a common cause of postoperative knee problems and should be high on the differential of the painful total knee. The best solution is preventative and not to allow it to occur in the first place. With the LCS, the early problem is obvious as implant dislocation or spinout will usually occur. The treatment is excellent revision surgical technique to correctly balance the flexion/extension gaps and offers gratifying surgical results with painfree well functioning total knees.

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Legend

1. Instability of LCS meniscal bearing total knee
2. Spinout or dislocation of an LCS Rotating Platform tibial insert. Note posterior tibial sag.
3. Clinical examination with varus/valgus testing
4. Clinical examination with anterior posterior drawer
5. Clinical examination with flexion stability testing, rocking the tibia with the knee flexion 90º and the knee totally relaxed
6. Femoral component options: dorsal movement of femoral stem, posterior and distal condylar builds
7. Flexion spacing block method, note spacing of anterior/posterior condylar cutting block based off intramedullary rod with anterior cortical reference