Fixed flexion deformities are common in osteoarthritic knees that are indicated for total knee arthroplasty (TKA). The lack of full extension at the knee results in a greater force of quadriceps contracture and energy expenditure. It also results in slower walking velocity and abnormal gait mechanics, overloading the contralateral limb. Residual flexion contractures after TKA have been associated with poorer functional scores and outcomes.

Although some flexion contractures may resolve with time after surgery, a substantial percentage will become permanent. Therefore, it is essential to correct fixed flexion deformities at the time of TKA, and be vigilant in the post-operative course to maintain the correction.

Surgical techniques to address pre-operative flexion contractures include: adequate bone resection, ligament releases, removal of posterior osteophytes, and posterior capsular releases. Post-operatively, extension can be maintained with focused physiotherapy, a specially modified continuous passive motion machine, a contralateral heel lift, and splinting.

Knee flexion contractures are common in osteoarthritic patients, having been estimated to occur in up to 60% of patients undergoing total knee arthroplasty (TKA). The definition of a knee flexion contracture is a knee that is unable to fully extend to 0°, either actively or passively. The aetiology of a pre-operative fixed flexion deformity is multifactorial; bony impingement, posterior capsular contracture, hamstring shortening, and ligament contracture all contribute to the inability to fully straighten the knee.

The clinical consequence of a fixed flexion deformity of the knee is that the quadriceps are forced to continually contract to avoid buckling, leading to a greater energy expenditure and resultant fatigue. One study demonstrated that a 15° flexion contracture led to a need for the quadriceps to contract with 22% more force than a fully extended knee; as the flexion contracture increased to 30°, the quadriceps had to contract with 50% more force. Patients with fixed flexion deformities experience tiring in standing, walking, and stair-climbing activities due to this increased demand on their quadriceps.

Furthermore, gait studies of patients with flexion contractures have determined that there are abnormal forces on the contralateral knee due to the limb length discrepancy and shortened stride length. The contralateral knee experiences increased extension and adduction moments of up to 15% greater with a fixed flexion deformity of 15°. Additionally, walking velocity decreases in a linear fashion with flexion contractures of between 15° and 20°. Trunk alignment may also be affected by a fixed flexion deformity, altering the kinematics of the spine. Residual flexion contractures after TKA can create similar problems and forces upon the contralateral limb. Using gait and force plate analysis, Harato et al confirmed that there was greater force placed on the contralateral knee if a flexion contracture persisted after TKA. Theoretically, this situation can lead to greater wear of the cartilage in the contralateral knee, potentially accelerating the arthritic process.

Although some contractures after TKR may eventually resolve, if the lack of extension is greater than 15° three months post-operatively, it is likely to persist.

Prevalence and Risk factors

Ritter et al studied over 5 000 TKAs performed using a cruciate retaining implant, and found that at a minimum of three year follow-up, 3.5% had > 10° residual flexion contracture. Those patients with > 10° of flexion contracture had significantly lower Knee Society pain and function scores when compared to patients achieving full extension. The following were
found to be risk factors for residual flexion contracture > 10°: gender, age, and existence of a pre-operative flexion contracture of 5° or greater. Male patients were 2.3 times more likely than women to have a residual contracture. Every decade of age increased the risk of contracture by 35%. The strongest risk factor for post-operative contracture was the presence of a pre-operative contracture, which is similar to studies that have shown the best predictor of post-operative range of motion is pre-operative range of motion. Goudie et al have quantified this risk as 2.3 times greater risk of a residual fixed flexion deformity if there existed a pre-operative fixed flexion deformity. Increased body mass index was not found to be a risk factor; in fact a higher BMI was associated with a lower probability of a post-operative flexion contracture.7,8

Surgical technique clearly plays a role in the potential for residual flexion contracture. Since the extension gap will be tighter in the knee with a fixed flexion deformity, sufficient space must be created for the knee to reach full extension. Therefore, overstuffing of the extension space must be avoided. Implant positioning also influences post-operative range of motion; if the implant is placed in flexion relative to the femoral axis, this will limit the arc of motion due to constraints of the articulation (Fig. 1).

**Surgical technique**

Recognition of the problem pre-operatively is necessary to be able to effect a cure surgically. Examination under anesthesia is helpful in the confirmation of a fixed flexion deformity, eliminating pain as the reason that a patient may not be fully extending the knee. It also allows the surgeon to evaluate the magnitude of contracture, to prepare for the steps intra-operatively necessary to correct the deformity. For instance, a fixed flexion deformity of 10° or greater will automatically guide a surgeon to resect an additional 2 mm of distal femoral bone.

Release of the posterior cruciate ligament will help correct fixed flexion deformities, as it is often foreshortened in the contracted knee. The author’s preference is to use a posterior stabilised knee implant and perform the release during the exposure, prior to the tibial resection. In a cruciate retaining TKA procedure, the PCL may have to be released at its insertion point to aid in balancing the flexion and extension gaps.9 Furthermore, a decrease in the posterior slope of the tibial cut will aid in the correction, since every degree of posterior slope equals a degree of residual flexion contracture.

It is helpful to have an adjustable cutting block for the distal femoral resection (Fig. 2). This allows an additional resection beyond the standard cut, in order to increase the extension gap. Clearly, a flexion contracture of greater magnitude will require a greater distal femoral resection. In general, for each 10° of flexion contracture, the author takes an additional 2mm resection (up to a limit of 6 mm). For pre-operative flexion contractures of >30°, the collateral ligaments are often shortened and require release; therefore, a more stabilised implant such as a hinged implant may be necessary.

Checking the extension gap at multiple timepoints during the surgery allows the surgeon to make adjustments along the way, performing additional soft tissue releases or bony resections. The authors like to check the extension gap to ensure that the knee can fully extend at the following timepoints in surgery: 1) after the tibial and femoral cuts have been made; 2) after all the cuts have been made and the menisci and cruciate ligaments have been removed; and 3) with the trial implants in place. The use of spacer blocks and trial inserts allow for this.
Posterior osteophytes are often present and must be removed to avoid tension on the posterior capsule that would prevent full extension. The author performs the removal of posterior osteophytes after the bony cuts have been made and the knee is at 90° of flexion (Fig. 3). Placing lamina spreaders on the cut surface of the tibia and posterior femoral condyles, and a curved osteotome and curette facilitate this process. After performing these steps, if the knee still does not fully extend, a posterior capsular release is performed. The capsule can be released from the posterior femoral or proximal tibial attachments, but the author finds it easier to perform the release off the tibia. With the knee hyperflexed, the tibia can be subluxated anteriorly with an anterior drawer force. The capsule is then released from the posterior tibial surface using electrocautery for a distance of approximately 1cm.

Final femoral implant impaction must be performed in a way that avoids flexion of the component. If the implant does not have lugs that avoid this tendency to flex, than an implant holder or other device should be used to keep the implant co-linear with the femur. A curved curette can be used for this purpose by hooking it under the cam of a posterior-stabilised femoral component and placing an extension force during impaction. Lustig et al10 have demonstrated that deviation of the femoral implant in the sagittal plane of greater than 3.5° from the mechanical axis resulted in a 2.9 times greater risk of a residual flexion contracture.

Post-operative management
Surgeons must also be cognizant of the post-operative measures necessary to avoid a residual flexion contracture. Placement of a bolster under the ankle, to suspend the knee and put an extension moment on the joint is helpful. In cases of severe flexion contractures (> 30°), the author uses occasional plaster splints, and keeps them fully extended for 48 hours prior to starting their bending regimen. A knee immobiliser at night is helpful for patients who tend to sleep with their knees flexed. Patients must also be educated that achieving full extension is just as important as achieving flexion, and that they should never place anything behind their popliteal fossa as this will lead to flexion deformity.

The rehabilitation regimen must also emphasise achieving full extension; our patients begin with isometric quadriceps contractions immediately after surgery and continue this through their recovery. There is also a continuous passive motion (CPM) machine developed in collaboration with Hospital for Special Surgery that incorporates a static stretch splint into its frame (GameChanger™ CPM; Biodynamic Technologies, NY) (Fig. 4). This allows the CPM machine to put an extension moment on the knee and is helpful in reducing recalcitrant residual contractures.

Other measures that can be taken to enhance extension of the knee include placement of a shoe-lift on the contralateral side; by lengthening the contralateral limb, the operative leg will be forced to extend while walking. The use of a stationary bicycle with the seat placed higher will also force the knee to come into extension on the downstroke. Finally, extension bracing can be used, although most patients find this to be too painful and cumbersome to tolerate. Regular follow-up is essential, to monitor the progress of the patient and to reinforce the importance of gaining full extension.

Discussion
Fixed flexion deformities of the knee can be functionally limiting and physically debilitating due to the increase demands upon the quadriceps mechanism. After TKR, residual flexion contractures are associated with poorer clinical scores and greater forces upon the contralateral knee. Clearly, flexion deformities must be corrected post-TKR and the correction maintained in order to maximise functional results after surgery.

The algorithm for correcting a fixed flexion deformity begins with the recognition of the problem pre-operatively.
Following determination of the magnitude of the deformity, the following measures can be taken: an additional 2 mm of distal femoral bone resection (for contractures of 10° or more); PCL release; posterior capsular release; posterior osteophyte removal; and avoidance of implantation of the femoral component in flexion. Additionally, a decrease of tibial cut posterior slope is helpful for avoiding residual flexion contractures in cruciate retaining systems.

For those patients with several contractures > 30°, the collateral ligaments may be shortened, requiring lengthening via pie-crusting or release at the origin. When collateral ligament lengthening is carried out, a more stabilised implant such as a constrained condylar knee or hinged knee prosthesis will often be necessary. Finally, the postoperative therapy regimen must be tailored toward maintenance of full extension, including the use of splinting, extension CPM, and shoe-lifts, and close monitoring.

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References