The stiff total knee arthroplasty
CAUSES AND CURES

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Seven stiff total knee arthroplasties are presented to illustrate the roles of: 1) manipulation under general anesthesia; 2) multiple concurrent diagnoses in addition to stiffness; 3) extra-articular pathology; 4) pain as part of the stiffness triad (pain and limits to flexion or extension); 5) component internal rotation; 6) multifactorial etiology; and 7) surgical exposure in this challenging clinical problem.

Technical skill is mastery of complexity, but creativity is mastery of simplicity
The Cambridge mathematician and topologist Christopher Zeeman, known for the term ‘arthrofibrosis’ and his contributions to ‘catastrophe theory’ said ‘technical skill is mastery of complexity while creativity is mastery of simplicity.’ Successful revision of the stiff total knee arthroplasty (TKA) will require the greatest technical skill and the ability to reduce complex failure (catastrophe) to a complete roster of simple problems: technical skill and creativity.

These are seven concise case presentations, each one illustrating a facet of the complex problems that come under the heading of the stiff TKA. Knee motion combined with stability epitomises the successful arthroplasty surgery. Satisfactory surgery requires a stable joint that extends fully with strength, and bends comfortably to a degree that permits normal activities. Ultimately, the limit of flexion in any TKA will be how far the quadriceps muscle can stretch. Accordingly, pre-op flexion is the major, but not the only, determinant of post-operative flexion.1

When surgeons describe an arthroplasty as stiff they mean that either extension or flexion fails to reach a certain expected point; usually full extension and some arbitrary amount of flexion, usually in excess of 90°. By contrast, patients often use the word stiff to describe the feeling of moving the joint. For example two doors may open and close fully. The one with rusted hinges requires greater force to reach the same point. Accordingly, a patient with full extension and flexion to 110°, may yet describe their TKA as stiff if motion is difficult.

Every complex mechanism requires all subsystems to function, for overall success. It is dangerous to accept stiffness in a TKA without analysis. This implies that the stiff TKA is one entity and implying further that everyone understands exactly what it is. Worse still is the use of arthrofibrosis, sounding as it does erudite and insightful, as a synonym for stiffness. Arthrofibrosis implies that stiffness results from the patient’s tendency to form scar tissue, and not in the arthroplasty. Obviously, if a surgeon believes that arthrofibrosis is the cause of stiffness, (as it may be in a minority of cases) then revision surgery should not be contemplated. Won’t that same unnatural tendency to form scar tissue simply make the revision stiff as well?

Case one: manipulation under general anaesthetic
A 68-year-old female presented for right TKA. She was pleased with her left TKA but had required a manipulation under general anaesthesia (MUGA) to achieve functional flexion. (Fig. 1a) The indications for both arthroplasties were painful osteoarthritis, in knees with reasonable flexion prior to surgery. The right TKA was performed uneventfully (Figs. 1b, 1c and 1d). The patellae tracked centrally, indicating correct rotational position of all components. She progressed slowly after surgery and a MUGA was performed eventually resulting in 115° of flexion. This case was straightforward: a patient, unwilling or unable to participate in effective physical therapy following TKA who benefited from MUGA. Nascent scars stretched easily while the patient was anaesthetised, and recovery returned to schedule.
Daluga and colleagues remind us that the recommendation for MUGA is not always straightforward. They compared 60 TKAs that required MUGA with 41 that achieved motion routinely. They found that an AP (antero-posterior) dimension of femoral prosthesis more than 12% greater than the patient’s femur was a critically independent variable that predisposed to manipulation, i.e., to stiffness. An oversized femoral component usually makes the TKA tighter in flexion and therefore stiff. Of all the TKAs that undergo MUGA, some will be perfectly balanced and benefit, while others may have some mechanical impediment to motion that MUGA cannot overcome.

The first lesson to learn from this case is that a TKA has either been performed adequately in all respects and so can permit motion up to the limit imposed by quadriceps flexibility or there is some inherent feature that mechanically limits motion. The second lesson to learn is that arthrofibrosis may be one cause of stiffness, but the two terms are not synonymous. If a TKA is stiff there will be scar. It doesn’t mean that the scar caused the stiffness.

**Case two: systematic and comprehensive diagnosis**

Stiffness may result from more serious problems, in which case manipulation alone will fail. In this case a 74-year-old male presented with a stiff TKA. Radiographs indicated a prior tibial tubercle transfer, as treatment for a dislocating patella (Fig 2). Our approach to every problem TKA is 1) systematic and 2) comprehensive.

- **Systematic** means that the same disciplined evaluation should be followed for each case. We use a worksheet that lists the eight indications for revision on the left, and on the right (Fig 2d), the necessary data that must be collected to confirm the diagnosis and plan corrective surgery. Infection tops the list, as it must be considered in every case. Simple diagnoses follow, some of which can be identified even over the telephone. The most
commonly made diagnosis ‘loosening’ is held in reserve to force us to consider all others first, and not jump to conclusions.

‘Comprehensive means’ that we consider every possible diagnosis, even having identified one compelling problem in a TKA. This patient presented with stiffness. It would be foolhardy to leave the assessment at that point. A systematic approach required that infection be considered first and indeed ESR and CRP were elevated, indicating the importance of an aspiration of synovial fluid. White cell count, differential and culture all confirmed the diagnosis of sepsis. Our comprehensive approach forced us to consider patellar tracking problems and their ineluctable association with internal rotation of tibia and or femoral components. The basic problem was internal rotation of tibial and femoral components. Incidentally, because of pain, scarring and patellar dislocation, the TKA was stiff.

The patient was treated with a two-stage re-implantation protocol for infection (Figs 2e & 2f). The re-implantation was performed with careful attention to rotational position of the tibial and femoral components, yielding a centrally tracking patella with increased comfort and flexion (Figs 2g to 2j).

This case teaches us that poor motion may be the result of another more fundamental problem with the arthroplasty.
and that no matter what else is wrong with the arthroplasty it may also be infected. Each TKA must be evaluated with a disciplined system and completely.

**Case three: extra-articular problems**

This 56 year old female patient was referred to our unit with a painful, stiff TKA. Her body mass index placed her in the super obese category. Several MUGA’s had been performed elsewhere. The last one resulted in a tibial frac- ture and loose component (Figs 3a & 3b). A systematic and comprehensive evaluation yielded a normal ESR and CRP, with low white cell count and differential in aspirated synovial fluid. Cultures of the fluid were negative, effectively eliminating infection as a cause of the failure. Radiographs of the pelvis, which we perform routinely prior to revision of the stiff TKA revealed extensive hip arthropathy (Fig. 3c).

That knee symptoms may arise from hip pathology has been understood for many years, and not just by orthopedic surgeons. Nonetheless, the diagnosis can be missed, perhaps because the patient is difficult to assess. The surgeons in this case were presumably so focused on stiffness, which they may have attributed to the obvious obesity that they neglected to fully evaluate the patient. While there are many demands on a clinician’s time, this diagnosis cannot be missed. This stiff TKA was interpreted as a nothing more complicated than a condition requiring manipulation. No aetiology was considered, and causes outside the knee joint were overlooked.

This case reminds us that stiffness can result from pain and that pain may originate outside of the knee joint.

**Case four: pain**

A 42-year-old woman presented with pain and stiffness in a TKA that had been performed for premature osteoarthritis in association with previous athletic injuries. She had wanted to remain reasonably active, but the results of surgery were disappointing (Fig 4). The TKA had a fixed flexion deformity of 15° and further flexion to 95°, which many surgeons might not consider stiff. She had difficulty bending the knee and it was painful. There was no evidence of infection and neither radiographs of the pelvis and lumbo-sacral spine, or a technetium bone scan, could locate a cause outside the knee. No findings other than pain indicated chronic regional pain syndrome.

Critical evaluation of the radiographs revealed that the femoral component was of an appropriate size, but had been implanted posteriorly, making the flexion gap smaller and tighter. Effectively, this component functions like one of a larger size, replicating the effect noted above and reported by Daluga. CT scanning revealed internal rotation positioning of the tibial component.

The patient described pain and stiffness, but had 95° of flexion. Revision arthroplasty with careful component sizing according to soft-tissue tension, balancing of flexion and extension gaps and rotational positioning of components was successful. The flexion contracture was eliminated but flexion increased only modestly from 95° to 110°. The patient, however, was pleased with decreased pain.

The stiff knee is usually a triad of flexion contracture, poor flexion and pain. We learned in 2001 from Barrack’s elegant case-control study comparing satisfied TKA patients with those suffering anterior knee pain, patients with otherwise unexplained anterior knee pain, had more internal rotation of femoral and in particular, tibial component position. If we identify the underlying problems in the TKA that presents primarily with stiffness and correct them, we stand a good chance of improving pain which is usually a very important part of the procedure. In other words, success may have more to do with reducing a feeling...
Case five: internal rotation

A 41-year-old athletic male, developed arthritis after an anterior cruciate ligament reconstruction and underwent a TKA complicated by pain and very poor motion. The knee lacked 10° of extension and flexed to only 45°. The pain was disabling. Good quality radiographs were impossible. When the prosthesis was imaged symmetrically, the limb is externally rotated (Figs 5a & 5b). When the limb was rotated correctly, the prosthesis could not be viewed well. The tibia was implanted in internal rotation and facilitated of painful tightness in a stiff TKA than with dramatic increases in the motion. Component rotational positioning is very important in understanding these arthroplasties.

This case illustrates the triad of the stiff TKA: 1) flexion contracture; 2) poor flexion; and 3) pain. There are usually several mechanical features that predispose to stiffness and pain. While the total amount of flexion provided by revision may be modest, function improves with elimination of flexion contractures and patients are grateful if the knee is more comfortable and moves more freely, even within a limited arc.
by patella alta, the patella was subluxing and would probably dislocate if the knee was flexed further (Figs 5c & 5d).

CT scanning is very useful in evaluating the stiff TKA and essential in this case. A validated protocol quantifies the rotational position of the tibial and femoral components, with four cuts: one through the femoral epicondyles and three through the proximal tibia. Tibial CT cuts image the component, the geometric center of the proximal tibia and the tibial tubercle. Given the asymmetry of the proximal tibia, up to 18° of internal rotation of the tibial component is permissible. This patient had a tibial component oriented at 42° of internal rotation. (Figs 5e to 5g).

By the time of revision arthroplasty, the knee had been so stiff over a prolonged period of time that the quadriceps had difficulty stretching. Gains in flexion were modest, correction of flexion contracture complete and the improvement in pain gratifying. Our experience with revision TKA demonstrated that one of the most consistent findings in the stiff TKA is internal rotation of the tibial component, usually the result of limited exposure and a desire to maximize coverage of the asymmetric tibia. It is difficult to discuss the stiff TKA now without quantitative CT scan data on rotational positioning of the components.

The lesson to learn from this case is that internal rotation predisposes to stiffness through maltracking. As the patient
flexes the knee and senses that the patella will dislocate, they become unwilling to flex further and never achieves functional flexion.19

**Case six: multi-factorial**

A 47-year-old female, four years after TKA presented with a stiff, painful TKA since surgery. There was a 5° fixed flexion contracture with flexion limited to 65°. Pain was severe and constant. The modular tibial polyethylene insert was thick, probably chosen to balance the extension gap and eliminate recurvatum in a patient who had a relatively small flexion gap. The posterior slope for this prosthesis is recommended to duplicate normal anatomy, but here there was virtually no slope, which tends to tighten the knee in flexion. The lateral view showed a thick patellar construct and the merchant view showed that the patella was trying to dislocate, indicating problems with rotational alignment of the tibial and or femoral components (Figs 6a, 6b and 6c).

Revision surgery that focuses on only one feature of this TKA will likely fail. The assessment must be analytical and detailed. Only a complete revision that can modify every variable in favor of greater motion over greater stability can be expected to succeed. Even with that, the elasticity of an extensor mechanism that has not been fully stretched in four years will ultimately limit motion.
The lesson to learn from this case is that stiffness complicating TKA is often a multi-factorial problem. Accordingly, complete revision arthroplasty is appropriate and lesser interventions are rarely successful. Although some of the first cases described above were used to illustrate specific single points, every one of them was revised with attention to all of the variables that we have covered.
Case seven: surgical exposure
A 67-year-old male presented with bilateral stiff TKAs with relatively little pain. His main complaint was that with only 35° of flexion bilaterally, should he fall to the ground, he would be unable to get up. He was involved in a road traffic accident that left him with solidly healed femur fractures and decreased flexion in knees that eventually developed arthritis. The arthroplasties performed on stiff knees, in turn, became even stiffer.

The argument can be made that his knees would be limited by the quadriiceps muscle stiffness even if revision was performed. The patient is adamant that he would like to proceed as the current situation is unacceptable. The surgical team feels that aggressive lysis of scar and revision to components that permit greater laxity in flexion, (i.e. smaller femoral component) combined with an assiduous physical therapy protocol may improve the situation. Even modest gains would be welcome (Fig. 7).

Many surgeons might recommend a tibial tubercle osteotomy for exposure. I believe that approach is unnecessary in this situation, as well as limiting and risky for aggressive physical therapy. In addition, the tubercle osteotomy does not, in itself, liberate the patient and the knee from extensive scarring. Surgical access might be excellent, but once the procedure is complete and the tubercle fixed back to the tibia, the extensor is stiff. The patellar turn-down is outdated23, the V-Y plasty misguided21-23 (lengthening the extensor mechanism often leaves the patient with a disabling lag even if it increases flexion) and the quadriiceps snip is of limited effectiveness.24-27

The surgical approach must include: synovectomy, re-establishment of the parafemoral gutters, quadriiceps liberation from the scarring that adheres to the anterior femur, scar removal from around the patellar tendon and sometimes a lateral patellar retinacular release for exposure, not patellar tracking. Ultimately, release of the proximal medial capsule and deep collateral ligament permits safe external rotation of the tibia. This drives the tubercle laterally, dislocating the knee. Non-linked constrained implants are useful generally in cases like these and will splint or supplant the medial soft-tissue envelope after the exposure. This has long been my approach for revision arthroplasty and has evolved concurrently and been reported by others as the, “Extensor Mechanism Tenolysis.”28

This case brings us full circle to stiffness that is primarily of soft-tissue origin, a case of arthrofibrosis. It poses specific and significant challenges in terms of surgical exposure.

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References