REVIEW ARTICLE

Stiffness in total knee arthroplasty

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Abstract Stiffness is a relatively uncommon complication after total knee arthroplasty. It has been defined as a painful limitation in the range of movement (ROM). Its pathogenesis is still unclear even if some risk factors have been identified. Patient-related conditions may be difficult to treat. Preoperative ROM is the most important risk factor, but an association with diabetes, reflex sympathetic dystrophy, and general pathologies such as juvenile rheumatoid arthritis and ankylosing spondylitis has been demonstrated. Moreover, previous surgery may be an additional cause of an ROM limitation. Postoperative factors include infections, arthrofibrosis, heterotrophic ossifications, and incorrect rehabilitation protocol. Infections represent a challenging problem for the orthopaedic surgeon, and treatment may require long periods of antibiotics administration. However, it is widely accepted that an aggressive rehabilitation protocol is mandatory for a proper ROM recovery and to avoid the onset of arthrofibrosis and heterotrophic ossifications. Finally, surgery-related factors represent the most common cause of stiffness; they include errors in soft-tissue balancing, component malpositioning, and incorrect component sizing. Although closed manipulation, arthroscopic and open arthrolysis have been proposed, they may lead to unpredictable results and incomplete ROM recovery. Revision surgery must be proposed in the case of well-documented surgical errors. These operations are technically demanding and may be associated with high risk of complications; therefore they should be accurately planned and properly performed.

Keywords Stiffness · Arthrofibrosis ·
Closed manipulation · Arthroscopic arthrolysis ·
Revision surgery · Knee prosthesis

Introduction

Prosthetic surgery has evolved as a safe and satisfactory procedure in the treatment of degenerative pathologies involving the knee joint. More than 350,000 primary replacements and 29,000 revisions were performed in the United States in 2002 [1]. The increasing number of revision procedures has led to a better understanding of the different postoperative complications. Stiffness is one of the most complex, both in terms of pathogenesis and treatment as it represents a frustrating problem for surgeon and patient. Stiffness is defined by a range of movement (ROM) limitation often associated with persistent pain. Normal knee ROM ranges from 0 to 140°, while a ROM from 0 to 110° after total knee arthroplasty (TKA) can be defined as a good result. No consensus is present in literature about the precise definition of stiffness. Stiffness has been defined by Kim et al. [2] as a flexion contracture >15° and a maximum flexion <75°, by Yercan et al. [3] as postoperative ROM smaller than 10–90°, by Nicholls and Dorr [4] as a flexion contracture ≥20° and a maximum

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flexion ≤45°, by Scranton [5] as a maximum flexion ≤85°, and by Christensen [6] as maximum ROM ≤70°.

The situation is extremely variable even in terms of epidemiology: Kim et al. [2] report an incidence of 1.3%, Yercan et al. [3] of 5.3%, and Gandhi et al. [7] of 3.7%.

We believe a TKA should guarantee a postoperative ROM of 0–120°, even if a lower ROM (5–95°) is sufficient for most daily living activities. Scuderi [8] noted that a flexion of 65° is required to walk on a flat ground, of 70° to arise from a chair and of 90° to descend stairs. Laskin and Beksac [9] stated that walking on a level surface requires 45–55° of flexion, ascending or descending stairs about 85°, standing from a chair usually 95°, while kneeling requires 125°. These data are not always correlated with patient satisfaction: postoperative flexion of 80° is unsatisfactory in the case of preoperative flexion of 120°, whereas it may be acceptable in the case of preoperative flexion of 60°.

Materials and methods

Due to the complexity of this issue, we performed a literature review to have a better comprehension of the problem. We searched the generally accepted PubMed index with the following keywords: stiffness, arthrofibrosis, total knee arthroplasty, and total knee replacement.

The combination of stiffness and total knee arthroplasty resulted in 139 articles, the one of arthrofibrosis and total knee arthroplasty resulted in 34 articles, while the combination of arthrofibrosis and total knee replacement resutled in 35 articles. Finally, the association between stiffness and total knee replacement resulted in 140 articles. The available abstracts were then evaluated, and the articles that correlated the best with the issue were examined.

From the analysis of these articles, some risk factors and treatment guidelines emerged. Although the pathogenesis was not completely clarified, we identified preoperative, intraoperative, and postoperative risk factors for stiffness. Moreover, according to the degree of ROM limitation, pathogenesis, and delay from the onset of the symptoms, some treatment options can be proposed: closed manipulation, arthroscopic or open debridement, and revision surgery.

Pathogenesis

General factors

In the pathogenesis of a stiff knee after TKA, several factors such as patient-related factors, surgical technique errors, and postoperative complications should be considered.

Patient factors include preoperative ROM, preoperative diagnosis, body habits, and patient personality [8]. Preoperative ROM reduction is the most important risk factor for postoperative stiffness [10]. This limitation may be the result of extensor mechanism and capsule contracture, posttraumatic arthrosis, and previous septic arthritis. Different pathologies such as juvenile rheumatoid arthritis and ankylosing spondylitis seem to play a role in the development of postoperative stiffness. Moreover, Jordan et al. [11] report the results of 17 total knee arthroplasties in patients affected by poliomyelitis, showing two cases of postoperative stiffness. Body mass index is not strictly related with postoperative ROM, especially in the case of trunk obesity and thin legs. On the other hand, flexion reduction may be caused by posterior impingement due to subcutaneous fat. Moreover, a correlation with general pathologies such as diabetes [7, 11, 12] and lung disease [11] has been shown. Comorbidities such as heart disease and hypertension seem not to affect the final outcome after total knee arthroplasty, nor do alcohol, preoperative narcotic, and nonsteroidal anti-inflammatory drug use [11]. Smoking, however, has a negative influence on postoperative ROM [11]. Previous surgery of the involved knee is an important risk factor: Scranton [5] reports that 85% of the patients with a stiff knee after TKA have had previous surgery or diabetes mellitus (Fig. 1). Age seems to play a controversial role; some authors reported a higher incidence of postoperative stiffness in younger patients undergoing TKA [11, 13]. Work status has an influence on postoperative results: retired patients were 1.5 times less likely to have stiff/poor result, whereas patients with disability or those not working due to knee pain were 5.8 times more likely to have stiff/poor result [11].

Reflex sympathetic dystrophy is a particular condition characterized by knee pain and stiffness. It is present in 0.8% of patient undergoing TKA [14]. Diagnosis is difficult as common exams are often normal. Patients describe delayed functional recovery, severe pain, vasomotor alterations, and trophic changes. Skin hypersensitivity, low local temperature, and hyperhydrosis may be present.

Fig. 1 Previous surgery is a risk factor in stiffness development

Flexion is more often affected than extension. Patellar osteoporosis may be present in X-rays, and bone scan shows a diffuse hyperfixation. In the case of early diagnosis (less than 6 weeks), gentle mobilizations and anti-inflammatory drugs are sufficient; conversely, in the case of late diagnosis (more than 6 weeks), lumbar sympathetic block may be necessary. This procedure is both diagnostic and therapeutic, since in the case of nonresponse, the diagnosis should be reconsidered. Several blocks may be required for the resolution of complete symptoms.

Finally, a positive attitude to perform rehabilitation correctly plays an important role in functional recovery: depressed patients and patients with low threshold for pain are at risk of difficult rehabilitation [15].

Surgical errors

Most frequent causes involved in the development of postoperative stiffness are related to surgical errors. These include errors in soft-tissue balancing, component malpositioning, and incorrect component sizing [6, 8].

In the case of cruciate-retaining prosthesis, a too tight posterior cruciate ligament limits the degree of maximum flexion, while a too loose posterior cruciate ligament causes an excessive femoral anterior translation with an impingement of the extensor mechanism. In the case of fixed varus deformity greater than 15–20°, the posterior cruciate ligament is involved in the deformity, and its resection or at least a wide release is necessary [16, 17].

Excessive femoral component hyperflexion may cause potential block to full extension and excessive tension on the medial and lateral retinacula; excessive hyperextension may lead to anterior notching and limited flexion [9]. Traditional intramedullary guides align the femoral component to the anatomic axis which is slightly hyperflexed if compared to the lower limb axis. Excessive tibial slope increases the posterior space leading to a loose PCL in cruciate-retaining implants. Insufficient tibial slope creates a smaller posterior space with flexion limitation. Most authors suggest the amount of posterior slope resulting from bony resections and insert slope should match the preoperative articular slope [9].

Excessive "patellofemoral" thickness is the consequence of an excessively anterior implant (in the case of posterior reference), an insufficient patellar resection, or an oversized femoral component (Fig. 2). An increase of more than 4 mm is considered pathologic [18].

Incorrect joint-line height is a potential cause of ROM limitation. Lowering the joint line leads to a patella alta and to tight retinacula causing pain and limited flexion. Raising the joint line leads to a patella baja and to an impingement with the polyethylene insert causing anterior knee pain and limited knee flexion [19] (Fig. 3).

Fig. 2 Oversizing in the femoral component causes increase in patella contact stresses with persistent anterior knee pain and ROM reduction

Fig. 3 A patella baja may lead to an anterior impingement with the polyethylene insert and flexion limitation

Errors in bony resection may cause flexion–extension mismatch with ROM reduction.

A proper distal femoral cut allows a good soft-tissue balance in extension. An insufficient posterior condyles resection may cause excessive tension on the collateral ligaments and PCL (if preserved) with consequent limited flexion. The possible solutions are a smaller femoral component (small anteroposterior diameter) or lowering the distal femoral cut using a thinner polyethylene. On the other hand, an excessive posterior condyle resection leads to a loose knee in flexion; a distal femoral recut using a thicker polyethylene would balance the knee both in flexion and extension.

Concerning the distal femoral resection, an insufficient resection leads to a stiff knee in extension. A distal femoral recut and posterior capsule release would be necessary to solve this problem. An excessive distal femoral resection leads to a loose knee in extension; a smaller femoral component (smaller antero-posterior diameter) with a thicker polyethylene allows a balance in flexion and extension. Posterior osteophytes often cause an extension contracture, and accurate removal is always necessary. The previous factors limit intraoperative range of motion, and this situation becomes even worse in the postoperative period. Other errors are difficult to detect intraoperatively, but usually become evident as the rehabilitation goes on. For example, the malrotation of the femoral component is difficult to detect during surgery but may cause patellofemoral kinematics alterations and microtraumatisms that lead to an inflammatory reaction and to an arthrofibrosis.

Finally, prosthesis fixation seems to play a less important role in the development of postoperative stiffness: Harvey et al. [20] do not report any difference between cemented and uncemented implants. Duffy et al. [21] report a slightly better postoperative flexion in the case of cementless implants ($102 \pm 18°$ vs. $100 \pm 19°$), although the only case of postoperative stiff knee was found in this group. Dodd et al. [22] report a postoperative ROM of 108 and 102° in the cemented and uncemented groups, respectively, at 6 months. By the 2-year FU period, the ROMs were equal. Three knees required manipulation under anesthesia (both knees of a rheumatoid patient and one knee in the cemented group) [22].

Postoperative factors

Infections may be a cause of ROM limitation. Usually they appear with few symptoms such as a difficult and slow rehabilitation. Systemic involvement with high temperature is uncommon. Pain is not always present. For these reasons, a postoperative stiff knee should always be considered as infected. *Staphylococcus epidermidis* is usually responsible for intense joint effusion and scar-tissue production. Arthrofibrosis is the most common cause of stiffness with an incidence ranging from 1.2 to 17% according to literature. It is caused by progressive production of abundant scar tissue between extensor mechanism and anterior femoral cortex with suprapatellar pouch obliteration, and medial and lateral gutters scarring down. No predisposing factors have been identified even if prolonged postoperative immobilization seems to be involved.

Aggressive rehabilitation is thus recommended and should start as soon as possible; the CPM (continuous passive motion) device allows a faster flexion recovery. Its role is essential in the first 3 months after surgery; later, it becomes almost useless. Joint haematomas may slow down rehabilitation and may develop an abundant fibrous tissue. Heterotrophic ossifications may cause postoperative stiffness; their incidence ranges from 3.8 [23] to 26% [24], and no correlation exists between their localization and the degree of stiffness. They are more frequent in the suprapatellar pouch and supracondylar region (up to 26% of the patients) [23, 24]. They are more frequent after wide surgical exposure, closed manipulation, and in patients with increased vertebral bony density. Some authors have noted an influence of Coumadin dosage after surgery [25]. Treatment consists of excision and physical therapy.

Sometimes stiffness is not caused by the knee itself but rather by problems affecting other joints. Clinical outcome can be influenced by hip or spine disorders. Hip flexion contracture or dorsal–lumbar kiphosis can lead to knee flexum. Their evaluation and treatment is important and should be performed before knee surgery. Moreover, in the evaluation of a stiff knee, several neurological or muscular pathologies should be considered [26]. Finally, proper rehabilitation is mandatory to obtain satisfactory articular motion: intensive passive motion and pain control must be performed immediately after surgery. Conversely, a too aggressive rehabilitation may lead to an inflammatory reaction with persistent pain and joint contracture.

Treatment

Prevention is the best way to treat a stiff knee. However, correct diagnosis is the first step to start a correct treatment. Beyond the special cases such as arthrofibrosis, heterotopic ossifications, and reflex sympathetic dystrophy whose treatment has been previously discussed, general treatment consists of the following options: manipulation, artrolysis (open or arthroscopic), and revision surgery.

Closed manipulation

This is a debated option, and its timing is critical. This procedure seems to accelerate ROM recovery in patients

with slow and difficult rehabilitation rather than allowing for a greater final ROM. Some authors suggest a closed manipulation in all patients not reaching 90° of flexion on the 10th day after surgery [27], others wait for at least 2 weeks [28]. The incidence of closed manipulations is therefore 54 and 23%, respectively. Esler et al. [29] suggest a closed manipulation in all patients not reaching 80° of flexion regardless of the delay from the surgical procedure. In general, the commonly accepted indication is a postoperative flexion inferior to 90° at 6 weeks, and the earlier this manipulation is performed, the more satisfactory is the result as showed by Daluga [30]. In the case of a too early manipulation, a risk of skin and soft-tissue damage is present; thus, a delay of at least 3 weeks from the surgical procedure is indicated. Its aim is to strip the fibrous bands that originate in the suprapatellar pouch in the case of incorrect rehabilitation. These bands become stronger and stiffer beyond 6 weeks with increased risk of complications such as patellar or femoral fracture or extensor mechanism rupture in the case of closed manipulation.

Manipulation should be performed under general or regional anaesthesia to provide adequate muscle relaxation, reducing the risk of complications. Once the effective ROM is recorded, a gentle force is applied to force the maximum flexion; mobilization of the patella is indicated, as it destroys the adherences in the suprapatellar pouch. This maneuver should be repeated several times for a complete lysis of fibrous bands. Postoperative management consists of continuous passive motion set to the maximum flexion and extension obtained. Pain control is essential: an epidural catheter is set in place for 24–48 h. Some authors stress the importance of pain management during rehabilitation and report that proper pain control reduces the necessity of closed manipulation from 9 to 1% [31].

Results seem satisfactory in the case of correct indications and precise technique: Yercan reports a ROM improvement from 67 to 117° [32], Pariente et al. [33] from 71 to 102° with his modified technique, while Scranton [5] reports an average gain of 36 and 35° if the manipulation is performed within 12 weeks and beyond this limit, respectively.

Surgical treatment

When the correct rehabilitation protocol is performed with no results for at least 6–12 weeks, no more improvements should be expected and surgical treatment should be considered.

Arthroscopic arthrolysis

Arthroscopic arthrolysis consists of lysis of direct adherences and is indicated in the case of arthrofibrosis in patients with a difficult rehabilitation. The ideal indication is a painless, stiff knee that has not improved after 3–6 months of conservative treatment, as reported by Court [34]. On the other hand, poor results are reported in painful stiff knee; this seems to be a consequence of wrong diagnosis [35].

This procedure guarantees a wide access to the suprapatellar pouch thus allowing good flexion recovery, while the access to the posterior part of the joint is extremely difficult or impossible. Thus, it is less effective in the case of extension lag. A PCL release or sacrifice is possible and is indicated in cruciate-retaining implants when a tight PCL is found. Its section leads to an immediate flexion gap increase and confirms that the diagnosis was correct. Foreign body removal (cement) is also possible under arthroscopy. Classic portals are sufficient in the majority of cases; if patellofemoral fibrosis is expected, then additional superior portals (medial and lateral) may be indicated. Synovial and scar samples are taken for a microbiological and histological analysis.

Jerosch describes a standard technique that consists of release of all fibrous bands in the suprapatellar pouch, re-establishing of the medial and lateral gutters, patellar release, and removal of remaining meniscal tissue or anterior cyclops. He reports a mean postoperative flexion of 119° and a decrease in extension lag from 27 to 4° [36].

Results after arthroscopic arthrolysis are rather controversial in the literature. Bocell et al. [35] report an increase in postoperative ROM in 43% of the patients, Williams et al. [37] an average increase in ROM of 30.6°, while Mont et al. [38] report an average improvement of 31° in 94% of the patients. Best results are obtained in the case of isolated patellofemoral fibrosis. As for the closed manipulation, best results are obtained in the case of early procedure. Most authors recommend not delaying beyond 6 months to avoid the scar tissue becoming strong and resistant. The importance of an aggressive postoperative protocol consisting of continuous passive motion and proper pain control after arthroscopic arthrolysis is now widely accepted [39]. In the case of severe ROM limitation, arthroscopic treatment alone is less effective, as demonstrated by Scranton [5], who noted worse results in the case of ROM ≤ 60°.

Open arthrolysis

Keeney et al. [40] recommend open arthrolysis in the case of a severe ROM limitation after TKA with no component malposition and after a proper conservative treatment performed for 6 months after surgery. It may be associated with polyethylene insert or patellar component exchange. Complete exposition may be difficult due to adherences,

and posteromedial corner release facilitates this maneuver. If patellar eversion is impossible, then tibial tubercle osteotomy or quadriceps tendon snip or VY plasty may be indicated. Suprapatellar pouch and medial and lateral gutters should be explored to look for fibrous bands. Posterior release is indicated to improve extension, while a 1- to 2-cm proximal transfer of the tibial tuberosity increases knee flexion and raises the patella with a minimal loss of quadriceps strength. Scuderi [8] proposes the quadriceps snip and tendon lengthening to improve maximum flexion with no extension or strength loss. Patellar resection is indicated in the case of overstuffing. In the case of flexion contracture, polyethylene downsizing is indicated.

Unfortunately, only a few reports are available in the literature concerning the results of open arthrolysis in the treatment of a stiff knee. In a Sofcot series, flexion and extension gains were 20 and 18°, respectively [41]; Hutchinson reported an increase from 55 to 91° 6 months after open arthrolysis [42]; and Pretzsch showed an increase in knee flexion from 46 to 90° and a decrease in flexion contracture from 11 to 7° [43]. In contrast, Babis reports poor results in the case of open arthrolysis and polyethylene exchange for stiff knees with fixed and well-aligned prosthetic component [44].

Revision surgery

In the case of documented surgical errors, any attempt to improve ROM must consider the resolution of these errors, making revision surgery necessary. Accurate analysis of these errors is essential to plan the revision correctly and to evaluate the expected benefits. In fact, functional results are usually unpredictable and ROM recovery may be poor. The incision should consider the skin contracture and fibrosis; scar excision should be avoided; and in the case of multiple incisions, the most lateral should be preferred. As previously mentioned, patellar tendon avulsion may occur due to its shortening, and fibrosis, tibial tuberosity osteotomy, quadriceps snip, or VY plasty are often required. Scar-tissue removal is performed in the same manner as in the case of open arthrolysis. Component stability, evidence of polyethylene wear, and patello-femoral track are carefully examined. Component removal may lead to bone stock loss especially in the case of uncemented implants, requiring wedge and augmentations to address this loss.

Great care should be taken with the patella, which is a cause of stiffness requiring revision surgery in 55% of the cases as shown by Bonnin et al. [45]. Patellar thickness is measured, since it is a common cause of stiffness when it is excessive. In the case of thickness greater than 26 mm in males and 24 mm in females, a resection is indicated [46]. Soft-tissue balance is performed both in flexion and

extension, and minimal symmetrical laxity in extension should be preferred to stiff knee. Considering the frequent recurrence of stiffness, some authors prefer to obtain a hyperextension of 5° at the end of revision surgery [47]. It has been proved that a tibial overresection of 1 mm increases the extension space by 4° [48].

The problem of joint-line level is still debated. Epicondiles are a good anatomical reference in joint-line restoration as described by Griffin. In unaffected knees, the medial epicondile is 27.4 ± 2.9 and 29.7 ± 2.7 mm from the joint line in coronal and axial planes, respectively. Lateral epicondile is 24.3 ± 2.6 and 25.0 ± 2.6 mm from the joint line in coronal and axial planes, respectively [49]. Excessive joint-line elevation leads to a patella baja and to loose collateral ligaments in flexion. Figgie et al. [19] state that an elevation up to 8 mm has no major consequences for the postoperative result. Unfortunately, in revision surgery, the epicondiles are not always clearly detectable; thus, the evaluation of the joint-line height may be difficult. Therefore, the distance from the inferior pole of the patella to the joint line has been proposed as a measure, and values greater than 1 cm are necessary to restore a proper height [19]. Component malpositioning in the frontal, sagittal, and coronal plane should be corrected to avoid stiffness recurrence. Frontal malalignments and rotational tibial and femoral errors should be corrected, as they affect both patellofemoral kinematics and soft-tissue balance. Postoperative results are unpredictable both in terms of articular recovery and clinical improvement.

Haidukewych et al. [50] in a series of revisions for stiffness report a ROM improvement from 40 to 73°, 66% of satisfactory results, and a further revision rate for stiffness of 25%. Dorr and Nicholls report fair and unpredictable results in the case of revision. Positive prognostic factors were malpositions and previous osteoarthrosis, and negative factors were patella baja and previous rheumatoid arthritis [4]. Nelson et al. [10] report an improvement of flexion contracture from 11.3 to 3.2° and flexion improvement from 65.8 to 85.4°. A postoperative ROM improvement was present in 93% of the patients.

Keeney compared the results of a limited approach (soft-tissue release and tibial insert downsizing) with those of a complete revision surgery. In the first group, there was an improvement in postoperative ROM (25.7°), clinical score (37.8 points), and functional score (20.8 points). In the second group, the improvement in postoperative ROM was 17.9°, in functional score was 3.6 points, while there was a decrease of 1.0 point in clinical score [40].

Bonnin [45] reported a ROM increase of 41° with associated symptoms improvement. In a SOFCOT series, there was a flexion improvement of 35° with an average postoperative flexion of 83°; moreover, an improvement in flexion contracture and pain score was noted [41].

Discussion

Stiffness is a frustrating complication after total knee arthoplasty. Its precise definition is still debated [2, 6]. Several factors contribute to its development and may be divided into preoperative, intraoperative, and postoperative.

Preoperative factors include preoperative ROM, and previous knee surgery and general factors such as diabetes, lung diseases, and smoking [11]. Reflex sympathetic dystrophy is a particular situation characterized by pain and stiffness [14].

Depression may compromise postoperative rehabilitation protocol and may therefore lead to a poor result after total knee arthroplasty.

Intraoperative factors include soft-tissue balancing mismatch, component malpositioning, and incorrect implant sizing [6, 8]. PCL management is crucial; its excessive tension is a source of flexion reduction. Moreover, joint-line variations may cause extensor mechanism unbalance and medial and lateral retinacula over-tension thus leading to ROM reduction and pain [19]. Tibial and femoral internal rotation affect both tibiofemoral and patellofemoral kinematics with inflammatory reaction and further arthrofibrosis.

Postoperative factors include arthrofibrosis and heterotopic ossifications and postoperative rehabilitation protocol. Thus, correct pain management in the first days after surgery seems mandatory to avoid these problems. Once the stiffness has been diagnosed, several options are available depending on its severity and cause and on the delay between the surgical procedure and the diagnosis. Closed manipulation is indicated in the first 2–3 weeks after surgery [27, 28]. It allows the fibrous bands that develop in the joint and suprapatellar pouch to be broken. In the case of correct indications, it guarantees satisfactory results [31–33]. Surgical options may be proposed after 6–12 weeks of a correct rehabilitation program. Arthroscopic arthrolysis is indicated in the case of stiff and pain-free knees. It is a good option, since it is a minimally invasive procedure and permits lysis of fibrous bands, PCL release, and removal of loose bodies. Unfortunately, clinical results are controversial and its indication is limited in severe cases [35–38]. Open arthrolysis is a more invasive option, and it allows a wide access to the anterior and posterior aspects of the joint. Moreover, polyethylene insert exchange is possible. Clinical results are generally satisfactory, although few articles are available in literature [41–43].

Revision surgery is the most aggressive and technically demanding option. It is indicated in the case of well-documented surgical errors. Patellar thickness, height, and tracking are a common source of problems leading to stiff

knee; therefore, they should be carefully evaluated [45]. Moreover, component malpositioning or oversizing should be corrected as should joint-line variations. Even in the case of a proper indication and precise surgical technique, results are sometimes unsatisfactory. Therefore, preoperatively patients should be carefully briefed on the unpredictable results following a revision procedure for stiffness.

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