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Review article

Patellar complications after total knee arthroplasty

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ABSTRACT

Patellar complications are a source of poor total knee arthroplasty (TKA) outcomes that can require re-operation or prosthetic revision. Complications can occur with or without patellar resurfacing. The objective of this work is to answer six questions. (1) Have risk factors been identified, and can they help to prevent patellar complications? Patellar complications are associated with valgus, obesity, lateral retinacular release, and a thin patella. Selecting a prosthetic trochlea that will ensure proper patellar tracking is important. Resurfacing is an option if patellar thickness is greater than 12 mm. (2) What is the best management of patellar fracture? The answer depends on two factors: (a) is the extensor apparatus disrupted? and (b) is the patellar implant loose? When either factor is present, revision surgery is needed (extensor apparatus reconstruction, prosthetic implant removal). When neither factor is present, non-operative treatment is the rule. (3) What is the best management of patellar instability? Rotational malalignment should be sought. In the event of femoral and/or tibial rotational malalignment, revision surgery should be considered. If not performed, options consist of medial patello-femoral ligament reconstruction and/or medialization tibial tuberosity osteotomy. (4) What is the best management of patellar clunk syndrome? When physiotherapy fails, arthroscopic resection can be considered. Recurrence can be treated by open resection, despite the higher risk of complications with this method. (5) What is the best management of anterior knee pain? The patient should be evaluated for causes amenable to treatment (fracture, instability, clunk, osteonecrosis, bony impingement on the prosthetic trochlea). If patellar resurfacing was performed, loosening should be considered. Otherwise, secondary resurfacing is appropriate only after convincingly ruling out other causes of pain. A painstaking evaluation is mandatory before repeat surgery for anterior knee pain: surgery is not in order in the 10% to 15% of cases that have no identifiable explanation. (6) What can be done to treat patellar defects? Available options include re-implantation (with bone grafting, cement, a biconvex implant, or a metallic frame), bone grafting without re-implantation, patellar reconstruction, patellectomy (best avoided due to the resulting loss of strength), osteotomy, and extensor apparatus allograft reconstruction.
Level of evidence: V, expert opinion.

1. Introduction

Patellar complications of total knee arthroplasty (TKA) are fairly common [1]. Despite a decrease in frequency related to improvements in implant design and surgical technique, they still account for about 10% of all TKA complications [2]. Patellar complications are dreaded as a source of poor outcomes. These may require repeat surgical procedures, which may fail to produce the desired outcomes if the mechanism underlying the complication is not identified and therefore, not specifically targeted. Exchange TKA may prove necessary if several treatment attempts fail. Extensor apparatus disruption was discussed by Bonnin et al. in 2016 [3] and will not be considered here.

We searched the literature to identify the diagnostic criteria and causes of patellar complications after TKA, with the goal of determining which treatments are most appropriate. Our objectives were to identify risk factors for post-TKA patellar complications and to define the optimal management of patellar fracture, patellar instability, patellar clunk, anterior knee pain apparently stemming from the patella, and patellar defects.

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2. Risk factors for patellar complications

2.1. Patient-related risk factors

Patient-related risk factors include pre-TKA valgus greater than 10° [4], obesity (with a body mass index greater than 30 being associated with 6.3-fold and 1.7-fold increases in the risk of loosening and fracture, respectively [4]), patellar thickness less than 18 mm [5], and patellar tilting or subluxation [6].

2.2. Surgery-related risk factors

2.2.1. Review article

A thin patella increases the risk of fracture and osteonecrosis when resurfacing is performed. A remnant bone thickness of at least 12 mm is recommended regardless of initial thickness [4,5].

2.2.2. An asymmetric bone cut

An asymmetric bone cut with a greater than 2-mm difference in medial vs. lateral remnant bone thickness is a risk factor when resurfacing is performed. Among 21 patients with asymmetric patellar bone cuts reported by Pagnano and Trousdale [7], over 50% experienced patellar complications requiring revision surgery (fracture, $n = 3$; loosening, $n = 1$; and pain, $n = 7$).

2.2.3. Patellar blood supply compromise

Patellar blood supply compromise due to lateral retinacular release is found in 50% of cases of patellar fracture [8]. Lateral retinacular release is associated with 3.8-fold and 2.7-fold increases in the risks of loosening and fracture, respectively [4].

2.2.4. Femoral and/or tibial rotational malalignment

Femoral and/or tibial rotational malalignment increases the risk of patellar instability [9].

2.2.5. A change in patello-femoral offset

A change in patello-femoral offset is of controversial significance. Matz et al. [10] reported no difference in pain between patients with and without a change in patello-femoral offset, whereas Kandhari et al. [11] found a decreased range of knee flexion when offset was increased.

2.3. Prosthesis-related risk factors

2.3.1. Femoral implant

The first femoral implants had a shallow trochlear groove with an elevated lateral shoulder as this was believed to optimize patellar tracking. Contemporary implant designs feature a narrower trochlear angle but remain somewhat 'dysplastic', as the groove is shallow [12]. When resurfacing is not performed, excessive height of the prosthetic trochlea is associated with an increased risk of secondary resurfacing [13].

2.3.2. Patellar implant

The introduction of all-polyethylene dome-shaped patellar implants has decreased the frequency of femoro-patellar complications. Complications related to the patellar implant include loosening and rapid wear of the thin polyethylene coating on metal-backed implants, which can lead to disassociation and to metallosis (due to contact of the metal backing with the prosthetic trochlea) [14].

Other patellar implant designs offer greater congruity with better stability. However, their positioning is technically demanding and the risk of wear greater [12]. In addition, these patellar implants may be a poor match with a different prosthetic design used for exchange TKA. In contrast, the dome-shaped implant is universally suitable.

Fixation with a single central peg has been suggested to increase the risk of fracture [4].

Numerous cementless implants with a porous tantalum anchoring surface have been developed recently. They should be viewed with circumspection given the 20% 2-year fracture rate observed in a study of 30 patients [15].

The frequency of patellar complications is not different between inlay vs. onlay patellar implants [12].

In patients with primary TKA studied by Lewis et al. [16], the frequency of patellar complications was 1.18-fold higher when the patellar implant was unmatched (14,688 cases) versus matched (197,146 cases) to the femoral component. This factor was not associated with the risk of revision surgery.

In sum

- To minimize the risk of fracture, a remnant bone thickness of at least 12 mm is recommended when resurfacing is performed.
- Risk factors for patellar complications include valgus, obesity, lateral retinacular release, and a thin patella before and/or after surgery.
- Patellar implant selection is crucial: the prosthetic trochlea must be chosen to ensure good patellar tracking and suitability to TKA without resurfacing, and in primary TKA the patellar implant must be well-matched to the design of the prosthetic trochlea.

3. Management of patellar fracture

The mean incidence rate of post-TKA patellar fracture in a study by Chalidis et al. [8] was 1.19% [range, 0.15%–12%]. Patellar fracture may be caused by trauma or patellar osteonecrosis. Of the 539 fractures in this study [8], only 12% were related to trauma. The remaining 88% were identified during follow-up visits. Most cases of patellar fracture occur within 2 years after TKA.

If the patellar is not resurfaced, conventional internal fixation should be considered. More often, the patella is resurfaced, creating management challenges.

3.1. Diagnosis

Antero-posterior, lateral, and skyline radiographs usually provide the diagnosis. Computed tomography (CT) may be required in doubtful cases (Fig. 1).

Two questions must be assessed: Is the extensor apparatus intact? and Is the patellar button loose? The most widely used classification, developed by Ortiguera and Berry [17], distinguishes three types:

- type 1: intact extensor mechanism and stable implant;
- type 2: disrupted extensor mechanism, with a stable or unstable implant;
- type 3: intact extensor mechanism and loose implant:
  - adequate bone stock,
  - inadequate bone stock.

Type 3 is the most common, with 50% of cases [8].

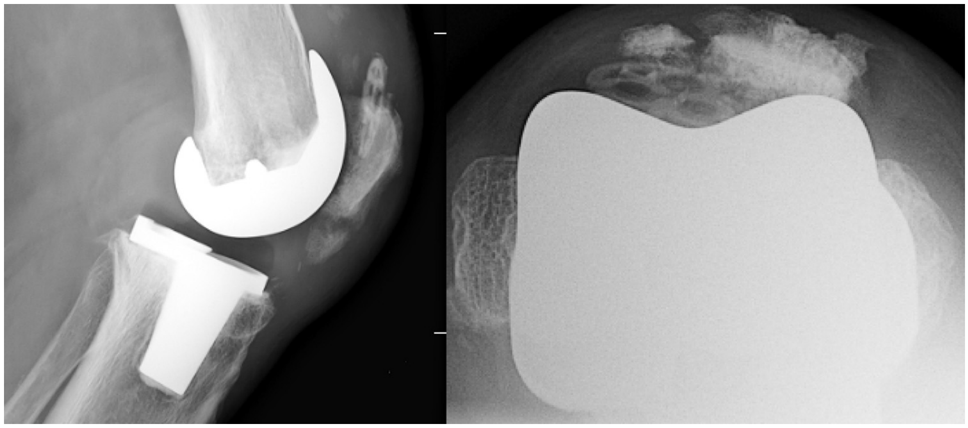

Fig. 1. Patellar fracture with loosening of the patellar button but an intact extensor apparatus.

3.2. Management

The management of post-TKA patellar fractures has been described by Chalidis et al. [8], as follows:

- intact extensor mechanism and stable implant (Type 1): non-operative treatment (splint, cast) is the rule;
- disrupted extensor mechanism with a stable implant (Type 2): in this situation, the fracture involves either the proximal or the distal pole of the patella. The implant is left in place to avoid fragilization of the residual bone, and the extensor apparatus is reconstructed [3];
- disrupted extensor mechanism with a loose implant (Type 2): surgery is usually required, with the primary objective of restoring a continuous extensor apparatus (trans-osseous suture, hamstring graft augmentation, allogeneic graft) [3]. The patellar implant must be removed;
- intact extensor mechanism and loose implant (Type 3): removal of the patellar implant is sufficient.

Chalidis et al. [8] reported a mean infection rate of 19.2% after surgery for patellar fracture and a risk of non-union of more than 80%. These data invite caution in the event of surgical treatment.

In sum

Two questions must be assessed:

- Is the extensor apparatus intact?
- Is the patellar implant loose?

If either is the case, surgical revision is required (extensor apparatus reconstruction, patellar implant removal).

Otherwise, the treatment is usually non-operative.

4. Patellar dislocation

4.1. Diagnosis

The diagnosis rests on clinical grounds but is confirmed by standard radiography (Fig. 2). The other knee must be examined also to look for distal epiphyseal rotational malalignment.

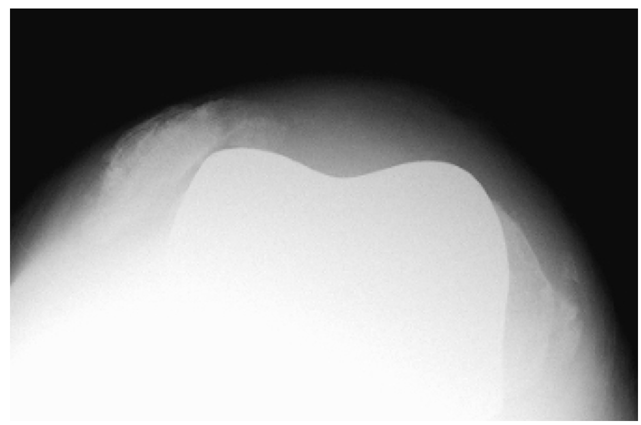

Fig. 2. Patellar dislocation.

4.2. Work-up

The work-up aims to accurately describe implant position [9]. Residual valgus of the TKA should be sought and CT performed to look for rotational malalignment.

4.2.1. Femoral implant malrotation

Two main parameters have been reported. The most widely used is the posterior condylar angle formed by the line tangent to the posterior condyles and the transepicondylar axis (Fig. 3). The other is the angle subtended by the line tangent to the posterior

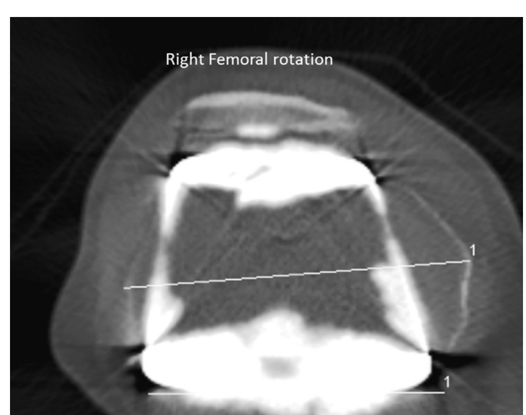

Fig. 3. Measurement of femoral rotation relative to the transepicondylar axis.

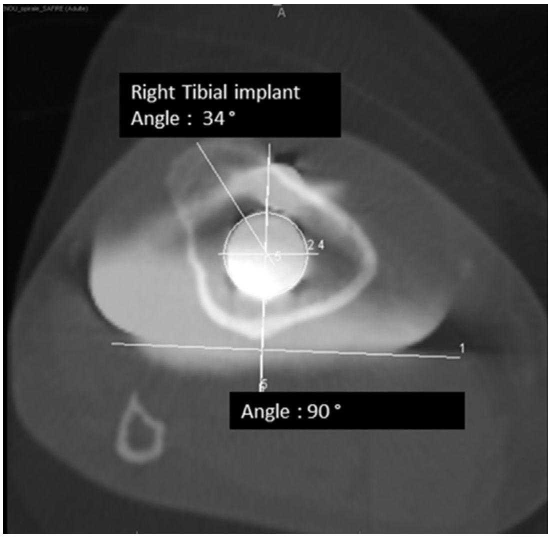

Fig. 4. Measurement of tibial tray rotation relative to the tibial tuberosity.

condyles and the axis of the femoral neck, which measures femoral anteversion [18].

4.2.2. Tibial plateau malrotation

Excessive internal rotation of the tibial plateau promotes external rotation during walking, thereby increasing the risk of patellar dislocation. The two main reported parameters are measurement relative to the tibial tuberosity as described by Berger et al. [9] (Fig. 4) and measurement of tibial torsion between the posterior edge of the metal tray and the center of the ankle, comparatively to the contralateral leg [19].

Internal femoral rotation promotes patellar instability and should be looked for first [18]. However, no threshold value has been determined [9–18].

For the tibia, Berger et al. recommended a threshold of $18^\circ \pm 2.6^\circ$ of medial tray rotation relative to the top of the tibial tuberosity [9].

Berger et al. advocated a combined analysis of femoral and tibial component rotation [9]. Combined internal rotation of 1° to 4° correlated with patellar tilting and maltracking, combined internal rotation of 3° to 8° with patellar subluxation, and combined internal rotation of 7° to 17° with patellar dislocation [9].

The work-up must also include an evaluation for other factors associated with instability such as patella alta [20] and non-medialized implantation of the patellar prosthesis [21].

4.3. Management

In patients with substantial rotational malalignment, prosthesis exchange deserves consideration. However, no validated threshold values are available.

Otherwise, surgical procedures similar to those used to treat patellar instability in native knees can be performed. Lamotte et al. [22] recently reported medial patello-femoral ligament (MPFL) augmentation using hamstring tendons in 6 patients and recommended this procedure in the event of preoperative patellar subluxation.

Attachment of the MPFL to the patella is difficult when the patella is prosthetic, and anchors deserve preference for fixation. Van Gennip et al. [23] reported reconstruction using the quadricipital tendon as a means of avoiding challenges with patellar fixation [23]. Outcomes were favorable in 9 patients, including 2 who also underwent tibial tuberosity transfer [23].

Tibial tuberosity osteotomy can be used alone or in combination with MPFL reconstruction. However, presence of the prosthetic stem is a complicating factor. In addition, complications include haematoma, skin necrosis, and non-union [24]. Whiteside and Ohl [25] developed a technique to improve stability and enhance union of the tibial tuberosity fragment. This technique consists in leaving a bony bridge under the tibial tray. With all these techniques, it makes sense to add lateral retinaculum release.

Several strategies have been suggested for patients with intra-operative patellar dislocation or subluxation in the absence of component malalignment. One such strategy consists in lateral retinaculum release, via an intra- or extra-articular approach [21]. Care should be taken to preserve the lateral superior genicular artery. With the extra-articular approach, the release must be more extensive and must be performed deep to the fascia to preserve the blood supply to the skin [26]. Lakstein et al. [27] reported using lateral patellar facetectomy to good effect (less than 2° of patellar tilt and less than 2 mm of patellar translation). Finally, Whiteside [28] reported no cases of dislocation or subluxation at last follow-up in 31 patients managed with distal realignment.

In sum

- The first step consists in looking for implant malrotation.
- If significant malrotation is found, exchange TKA should be considered.
- Otherwise, options include MPFL reconstruction and/or medialisation osteotomy of the tibial tuberosity with lateral retinaculum release.

5. Clunk syndrome and crepitus

5.1. Diagnosis

The diagnosis rests on clinical grounds. The clunk occurs during active knee extension, at about 30° to 45° of flexion. The clunk consists of both a sound and a catching sensation. It is caused by a scar tissue nodule developed above the patella (Fig. 5). The nodule becomes entrapped within the intercondylar box of the postero-stabilised femoral component [29].

Crepitus is produced by the intra-articular bands of fibrosis [29].

Clunk syndrome and crepitus occur in 0% to 18% of patients. Clunk syndrome is seen almost only with postero-stabilised designs, although 2 cases have been reported with a bi-cruciate-retaining design [30].

Risk factors have been suggested, although not consistently identified. They include an undersized femoral or patellar component, thin patella, implant overhang at the distal pole, increased posterior offset, and forced knee flexion. However, the main risk factor is an intercondylar box that is too wide and has excessively sharp edges [29]. Martin et al. [31] reported that using a narrower intercondylar box with a slimmer trochlea nearly eliminated the occurrence of clunk syndrome. As a preventive measure, excision of the supra-patellar synovial membrane during TKA is recommended [30].

5.2. Management

Gholson et al. [32] reported good outcomes with exercises to stretch the quadriceps and hamstrings. Of 46 patients with clunk syndrome or crepitus, only 18 required surgery.

The most widely used surgical technique is arthroscopic resection of the supra-patellar nodule, which provides good outcomes

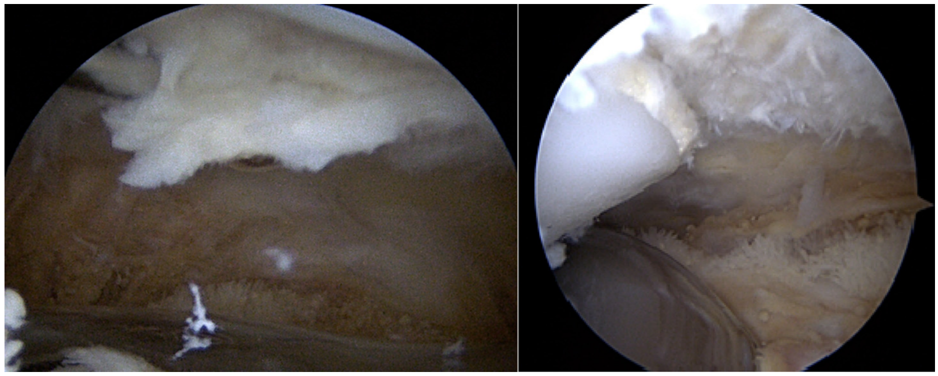

Fig. 5. Clunk syndrome: a: arthroscopy findings in clunk syndrome: note the supra-patellar nodule; b: image after arthroscopic resection.

(Fig. 5). Costanzo et al. [33] reported only 4 recurrences in 75 patients, with similar outcomes at last follow-up to those seen in patients without clunk syndrome. Open surgery allows a more extensive excision but carries a risk of complications (infection, extensor apparatus disruption) [34] and is therefore reserved for failures of arthroscopic treatment.

In sum

- The diagnosis of clunk syndrome rests on clinical grounds.
- Physiotherapy should be used first.
- When physiotherapy fails, arthroscopic resection can be performed and provides good outcomes. Open surgery for nodule excision is reserved for the treatment of recurrences and carries a higher risk of complications.

6. Management of anterior patellar pain

Anterior patellar pain is seen in up to 20% of TKA patients [35]. Determining the cause is challenging. A mechanism linking the anterior knee pain to a patellar complication must be demonstrated. Park et al. [35] found no explanation in 10% to 15% of cases and recommended reserving surgery for patients in whom the source of pain had been convincingly documented: clunk syndrome, rotational malalignment [36], patellar necrosis, impingement of the patella on the prosthetic trochlea, loosening, asymmetric patellar cut, or absence of resurfacing.

6.1. Avascular necrosis of the patella

Avascular necrosis of the patella causes persistent anterior knee pain. Other presentations include a patellar fracture in the absence of any traumatic event and a break in the skin over the patella [37]. Scintigraphy and/or CT may assist in the diagnosis by showing an increase in density with bone tissue sclerosis (“white patella”) [38]. When there is no fracture or implant loosening, the treatment is usually non-operative. A loose implant must be removed if the extensor apparatus is intact; otherwise, reconstruction is in order. If the implant is stable, in contrast, regular follow-up seems reasonable.

6.2. Impingement of the patella on the femur

The lateral part of the resurfaced or unresurfaced patella can impinge on the prosthetic trochlea, causing pain (Fig. 6) [39]. The diagnosis rests on the elicitation of pain by finger pressure on the lateral patellar facet. Crepitus may be produced at the site of the pain. The skyline radiograph confirms the lateral impingement.

Cercek et al. [40] reported that lateral facetectomy combined with lateral retinaculum release was followed by a significant improvement in the International Knee Society (IKS) score after 1 year. Wachtl and Jacob [39] obtained good outcomes with lateral facetectomy alone, despite persistence of minor lateral tilt in 15% of cases.

As a preventive measure, partial lateral facetectomy can be performed during TKA [27].

6.3. Loosening of the patellar implant

Isolated patellar implant loosening can raise diagnostic challenges. The incidence of this complication has ranged across studies from 0.4% to 4% [1] and has decreased since the introduction of dome-shaped patellar implants.

The radiographic diagnosis is often difficult, and scintigraphy and/or CT are helpful.

Rath et al. [41] reported difficulties in diagnosing 4 cases of loosening at the cement-implant interface and recommended arthroscopy to test the patellar implant in doubtful cases.

Apparently isolated patellar implant loosening should prompt a search for another source of pain, which would result in a poor outcome after repeat surgery confined to the patella. Many treatments, depending on patellar thickness and bone stock, have been suggested and are discussed below (section 7).

6.4. Asymmetric patellar cut

The diagnosis relies on demonstration of a greater than 2-mm difference in remnant bone thickness between the medial and lateral sides on the patellar radiograph and CT views (Fig. 7) [7]. Anglin et al. [42] reported asymmetric patellar cuts in up to 10% of cases, with female gender and a dysmorphic patella being risk factors that warrant particularly close monitoring.

Nevertheless, no recommendations exist about managing patients with an asymmetric patellar cut found on follow-up skyline radiographs. Simple monitoring is advocated in the absence of pain. When pain is present, whether it is related to the cut asymmetry is difficult to establish. Revision surgery may require a challenging bone reconstruction procedure.

6.5. Pain after TKA without patellar resurfacing

Patellar denervation has been suggested to prevent pain when patellar resurfacing is not performed. However, the effects seem to wane over time [43]. Cerciello et al. [44] found that patelloplasty (osteophyte resection) was better than simple denervation.

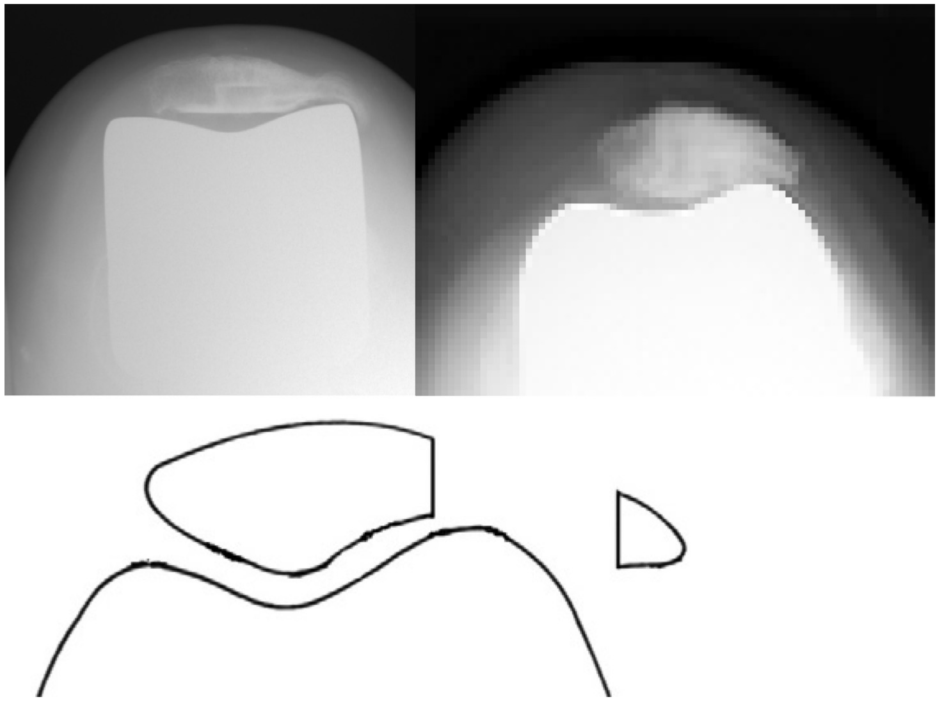

Fig. 6. Patellar impingement: a: impingement of the bony patella on the trochlea; b: suggested lateral patellectomy procedure.

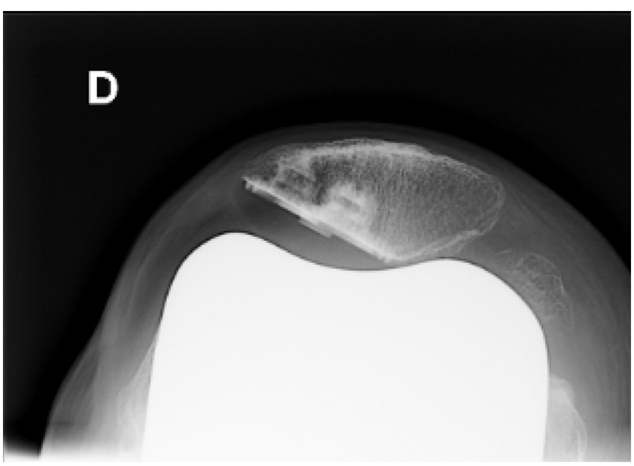

Fig. 7. Malposition of the patellar button, which is over the medial edge of the patella.

Patellar resurfacing may seem an appealing option in patients with persistent anterior knee pain, particularly when serial radiographs show progressive patello-femoral joint line narrowing and lateral bony sclerosis. In a review of 15 studies of secondary patellar resurfacing, Van Jovenbergh et al. [45] found that only 64% of patients were satisfied and that the complication rates were 2.2% for infection, 2.2% for wound healing problems, and 1.5% for fractures [46].

Bhattee et al. [46] recommended looking for rotational malalignment before considering secondary patellar resurfacing. In patients with more than 3° of femoral component internal rotation, simple secondary resurfacing was associated with poor clinical outcomes in their experience.

In sum

- Persistent anterior knee pain should prompt an evaluation for the above-listed causes related to the patella. However, and importantly, other causes of pain must be ruled out.
- The decision to perform surgical revision for patellar pain should not be taken without an extensive work-up. It must be borne in mind that investigations fail to identify the source of the pain in 10% to 15% of cases, a situation that contra-indicates surgical revision.

7. Management of severe patellar bone deficiency

During revision surgery, severe patellar bone deficiency may preclude the insertion of a new patellar implant. At least 8 to 12 mm of cortical bone is usually required for patellar re-implantation [2,47]. During femoro-tibial revision, a patellar component that is stable and free of wear may be best left in place, given the challenges raised by re-implantation [47]. Many techniques have been suggested.

7.1. Patellar component re-implantation

This is the option of choice. If initial fixation was with a central peg, the hole can be filled and peripheral pegs used, or vice versa.

Patellar component re-implantation can be combined with the grafting of autologous bone from the bony cuts or iliac crest [48].

Seo et al. [49] described a technique involving trans-cortical wiring and filling of the defect with cement, into which the patellar implant is impacted. The 4-year survival rate was 96.4%, the clinical IKS score was improved at last follow-up, and only 1 of the 30 patients experienced a fracture.

Specific patellar implant designs can be helpful.

7.1.1. Biconvex implants

Ikezawa and Gustilo [50] used a biconvex patellar implant in 23 patients with a mean patellar bone thickness of 7.9 mm and a mean follow-up of 46 months. At last follow-up, there were no patellar fractures. Similarly, in 20 patients with a mean patellar bone thickness of 6.5 mm (minimum, 4 mm), Maheshwer et al. [51]

noted no cases of fracture or revision surgery after a mean follow-up of 34 months.

7.1.2. *Implant with a porous tantalum anchoring surface (Trabecular Metal™, Zimmer Biomet, Warsaw, IN, USA)*

In 23 patients with less than 10 mm of patellar thickness, Kamath et al. [52] noted an 83% survival rate after 5 years. Ries et al. [53] noted that residual bone stock for implant insertion was required, as loosening occurred consistently after fixation to the adjacent soft tissue.

7.2. *Bone graft reconstruction*

In 9 patients with 7 to 9 mm of patellar thickness, Hanssen [54] performed reconstruction with a morcellised bone graft, which was pressed into a pouch created by securing a tissue flap to the patellar rim. The functional outcome was satisfactory and mean patellar thickness was 19 mm after 2.5 years.

7.3. *Simple removal of the patellar implant with or without reshaping of the remnant patellar bone*

Patellar implant removal is a simple procedure than is indicated to treat loosening in patients with a thin patella and/or infection. However, Barrack et al. [55] reported poor outcomes (pain, extension lag, lateral subluxation, and patellar fragmentation). More recently, improvements in function scores and freedom from revision surgery were reported, suggesting gradual remodeling over time [56].

7.4. *Patellectomy*

Outcomes are poor after patellectomy. Chang et al. [57] reported outcomes of 8 patellectomies done to treat comminuted fractures after TKA. The extension lag was less than 10° but the knee function scores were poor.

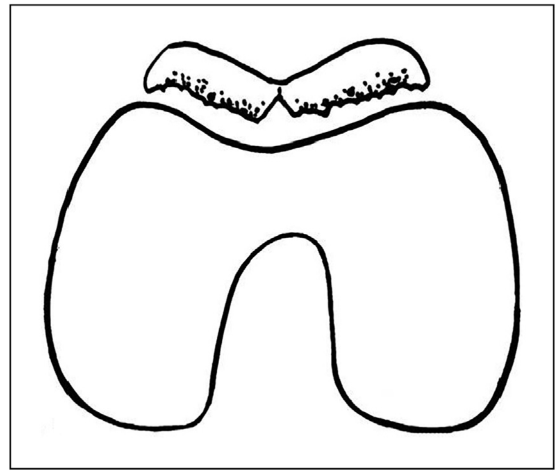

Fig. 8. Gull-wing reconstruction of the patella.

7.5. *Osteotomy*

Vince et al. [58] suggested a gull-wing osteotomy of the patella (Fig. 8). With this technique during TKA revision surgery in 13 patients, Gililland et al. [59] observed bone healing in all but 1 patient, a significant IKS score increase, a mean extension lag of 7.5°, and a flexion range of 90°.

7.6. *Allogeneic extensor apparatus grafting*

Busfield and Ries [60] recommended using an extensor apparatus allograft in patients with major patellar defects precluding reconstruction. In 6 knees, quadricipital force improved significantly but the complication rate was high (infection in 2 cases and allograft resorption in 1 case) [60]. Others have also reported that extensor apparatus allografts produced satisfactory clinical outcomes but only at the cost of high complication rates [61,62].

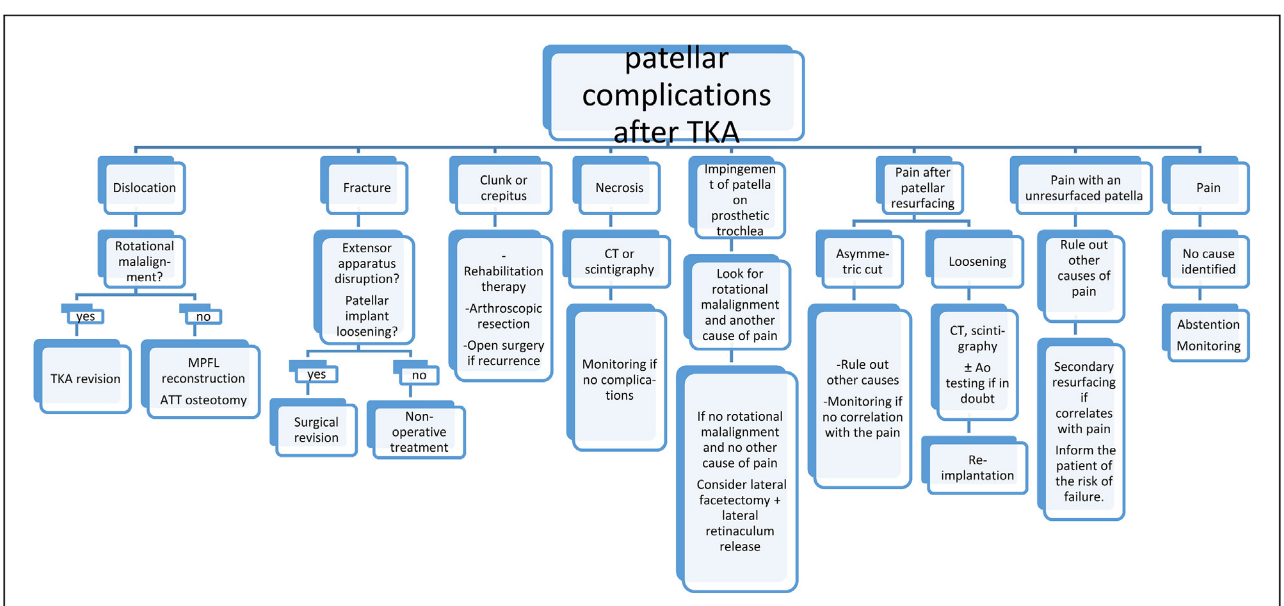

Fig. 9. Suggested management algorithm. ATT: anterior tibial tuberosity; Ao: arthroscopic.

In sum

When the patellar bone stock is severely deficient, available options include re-implantation (with bone grafting, cement, a biconvex implant, or a metallic frame), bone grafting without re-implantation, patelloplasty, patellectomy (best avoided given the resulting loss of strength), osteotomy, and extensor apparatus allograft reconstruction. None of these techniques has been proven superior over the others.

8. Conclusion

Patellar complications after TKA remain dreaded events. Awareness of the risk factors can reduce their frequency. Decisions to perform revision surgery for patello-femoral complications must be convincingly documented, with identification of the cause of the complication (Fig. 9). When no cause is identified, non-operative treatment is the best option, given the uncertain outcomes of the various available surgical procedures. Thus, among 361 TKA revisions for extensor apparatus complications studied by Cooney et al. [63], 23% required repeat revision surgical procedures, of which 33% were related to patello-femoral complications. These data invite caution.

Disclosure of interest

The authors declare that they have no competing interest.

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None.

Authors' contribution

Sophie Putman wrote the article.
Florian Boureau participated in data collection.
Gilles Pasquier, Julien Girard and Henri Migaud helped in writing.

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