The Challenge of Managing the “Third-Space” in Total Knee Arthroplasty: Review of Current Concepts

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Abstract

Total knee arthroplasty (TKA) is the best treatment for advanced knee osteoarthritis and it has proven to be durable and effective. Anterior knee pain (AKP) is still one of the most frequent complications after TKA, but sometimes no recognized macroscopic causes can be found. The correct treatment of patella is considered the key for a proper management of AKP. The inclusion of patellar resurfacing during TKA has been described as a potential method for the reduction of AKP. After surgeons started to resurface the patella, new complications emerged, such as component failure, instability, fracture, tendon rupture, and soft tissue impingement. Patelloplasty has been proposed as a good alternative to resurfacing but whether or not to resurface the patella is still a controversial topic in the literature. Therefore, patellofemoral joint is a complex critical aspect in TKA and choosing between the several options of treatment of patella could not be sufficient. In this review, evidence-based studies do not succeed in resolving this difficult argument. The accurate management of the so-called “third space” should include an accurate assessment of cartilage layers, balance of soft tissue, preoperative anterior tracking, and positioning of the femoral and tibial components. In fact, the selection of suitable implants and adherence to proper surgical technique are the fundamental principles for the success of TKA.

Keywords
► total knee arthroplasty
► patella
► resurfacing
► patelloplasty
► patellofemoral joint

Introduction

The patellofemoral (PF) joint (PFJ) is involved in over 45% of cases of knee osteoarthritis (OA), independently or concurrent with OA in the other compartments.1 Despite its incidence, few papers in the literature have focused on it. Patellar disorders are strictly linked to anterior knee pain (AKP) and sometimes it can be traced back to malalignment of the extensor mechanism.2 PF malalignments seem to have several predisposing intrinsic factors, such as neural inflammation, altered proprioception, patellar tendinitis, Osgood–Schlatter disease, coronal knee malalignment, and joint hypermobility.3–7 There are also some others causes of AKP that are not related to malalignment, such as inflammatory disease, tumors, infections, stress fractures, fat pad inflammations, and psychological causes.8,9

Total knee arthroplasty (TKA) is the most effective treatment for advanced knee OA. The intervention does not always include a resurfacing of the patella, even if PFJ is frequently
involved. PFJ is a critical aspect of kinetic features of the implant design in TKAs and is supposed that implant kine-
matics contributes to PF complications. A successful TKA
generally is able to increase knee flexion angle, thus enhancing
the PF contact and pressing forces.10

Long-term changes for nonresurfaced patella have been
described. Laughlin et al demonstrated how the lateral tilt
increases over time.11 Shih et al showed that in patients with
long-term follow-up the patellar tracking and the PFJ
remained normal in 60% of the TKAs, but progressive degen-
erative changes and patellar maltracking are common radi-
ographic findings. Retention of the native patella is associated
with progressive degeneration of the lateral patellar facet in
85% of cases.12

Patients with preoperative patellar maltracking could be
considered at risk of developing these abnormalities and
clinical symptoms. Indeed, leaving the native patella is related
to a high incidence of AKP, up to 47%.13,14 For this reason, some
authors recommend routinely resurfacing the patella.15,16

Nevertheless, some studies showed that patella complica-
tions in TKA are more frequent in the resurfaced group than
in nonresurfaced one.17–19 Some others suggested a selective
decision based on factors such as preoperative AKP, evalua-
tion of patellar thickness, severity of OA in the third compart-
ment, and the experience of the surgeons.20,21 Therefore,
during surgery, surgeons that do not routinely resurface the
patella should consider several issues, including the severity
of OA, knee alignment, PF tracking, implant design, and
position of the components.

If the surgeon decides to retain the native patella, several
options could be chosen to reduce the rate of AKP and
improve the outcomes. Options that have been described
include patelloplasty, deretration, and circumferential
resection of the osteophytes. Patelloplasty has been defined
as the surgical options aiming at the improvement of the
congruency between the patella and the trochlea, conduct-
ing a real reshaping of the patella.22

Despite the excellent records about the long-term out-
come of TKA, there remains controversy about the correct
management of the PFJ.

**Patellar Resurfacing**

In 1955, McKeever tried to reduce pain in PFJ OA by patella
resurfacing as an alternative to patellectomy or debride-
ment.2 Even though TKA has shown good results almost
since its creation, in the 1970s many physicians identified
AKP as a frequent complication of TKA. Since then, the
implants included the patellar component. This choice
resulted in reduction of incidence of AKP, but despite this,
complications related to resurfacing started to emerge.

Several designs and materials have been used for patellar
resurfacing. At the beginning, all-polyethylene patellar com-
ponents were used, but they presented with early deforma-
tion and accounted for almost 50% of all TKA revisions.23
Some years later, a metal backing was incorporated into the
design to give load transfer to the patellar bone and to allow
cementless fixations using a porous metal surface. Unfortu-
nately, new complications arose related to the shearing
forces between the polyethylene surface and the metal back-
ing under eccentric loads.24 One of the most frequent com-
lications, the polyethylene wear, resulted in exposure of the
metal backing leading to metal-on-metal contacts. Loosen-
ing and migration became frequent, leading to exposition of
the femoral metal to the patellar bone. Several studies
conducted onto the metal-backed patella reported 5 to 33%
failure rate.25,26 Later, engineers tried to modify the poly-
ethylene dome shapes to normalize the contact forces, thus
improving polyethylene wear patterns.27 The introduction of
a low-contact-stress press-fit metal-backed rotating patella
increased the congruity of the PFJ. These innovative designs
led to the reduction of contact pressure, which resulted in
fewer complications.28

Actually, modern prostheses incorporate an all-polyethy-
lene patellar component with pegs (from 1 to 3) and cement-
ted fixation, reducing the high risk of failure with the
cementless metal-backed implants.

The implants are available to the surgeons in the range of
8–10-mm thickness. A caliper should be used to measure the
central patellar thickness, with the aim of maintaining the
anatomical thickness. A residual bone thickness of approxi-
amately 15 mm is required.29 The patella resection is performed
with the aim of being flat. The implant is placed and generally
cemented, because, as we have previously said, complications
rate may decrease with cement. Medial placement of the
implant improves patellar tracking when compared with cen-
tral placement.30 Only if the patella tracks laterally or lifts off
medially, a lateral patellar retinacular release should be per-
formed. Some authors describe an additional lateral facetecto-
yomy, proper of patelloplasty, and it can be performed when a
malaligned patella is addressed. Open partial lateral patellar
facetectomy has been shown to improve function but with poor
correlation with radiological findings.31

Several complications can occur following patellar resur-
facing. Instability is probably the first one, requiring revision
surgery in about 0.5 to 0.8% cases. Factors that could con-
tribute to patellar instability include malposition of the
components, soft tissue imbalance, excessive femoral com-
ponent size, and inadequate patellar resection.32,33 Treat-
ments for instability are component revision, proximal and
distal realignment of the soft tissue, and osteotomy of the
tibial tubercle. The most dangerous complication is patellar
fracture (0.05–8.5% of TKA cases).34–36 Decreased bony
thickness combined with osteopenia, avascularity, trauma,
fatigue, and stress can generate this kind of adverse event,
whose risk increases when lateral retinaculum release is
simultaneously performed.37

Fractures may occur during surgery too: an extremely thin
patella is at higher risk of fracture due to the high mechanical
pressures. Patellar fractures are generally treated with a
conservative approach, especially when an implant is not
loose and the extensor mechanism is not disrupted, whereas
surgical options include open reduction with internal fixa-
tion, excision of fracture fragments, and patellectomy.38,39

Another complication is wearing of the patellar component
(incidence ranging between 5 and 11%).21 Factors that can be
associated to this complication are maltracking and abnor-
mal contact force. Maltracking is able to induce component
loosening in 0.6 to 1.3% of cases, as well as traumas. Soft-
tissue impingement, the so-called patellar clunk syndrome,
results from the formation of a fibrous nodule over the
patella proximal pole and is strictly associated with posterior
stabilized design. Generally, it can be treated through an
arthroscopic or open resection. The patellar ligament rup-
ture (0.22–0.55%) can be due to excessive dissection, knee
manipulation, and trauma. Either staple fixation or grafts
can be used in treating acute ruptures, but with poor outcomes.

The advent of modern prosthetic designs with better PF
congruence, smoother patellar tracking, and superior patel-
lar fixation, has led toward fewer patellar complications.
Recent studies have reported lower PF complication.

Some authors have proposed algorithms to assess the
ideal candidate to patella resurfacing. Bourne and Burnett
formulated five criteria for choosing the resurfacing option:
severe PF OA, poor tracking, inflammatory arthritis, obesity,
and age over 60. Several studies have denied all these beliefs:
no differences have been found between obese and nonob-
ese; no correlation has been proved with severity of OA; and
studies on alignment have also considered the correla-
tion between malalignment and necessity for a resurfacing,
without a certain result.

Some gross data derived from randomized clinical trials
(RCTs) seem to support those surgeons who are used to
resurface the patella. Anyway, some systematic reviews
and meta-analysis summarized that the decision is still diffi-
cult. Pakos et al. reviewed 10 RCTs that favored patellar
resurfacing when compared with the relative risk of revision
and AKP. Parvizi et al. conducted a meta-analysis on 14
studies, which proved that there was no difference between
resurfaced and un-resurfaced patellas in reoperation rate,
but showed that patellar resurfacing results in the reduction of
AKP and achieve better patient satisfaction. Nizard et al.
demonstrated a lower risk of reoperation for resurfaced patella
with respect to un-resurfaced (0.43 vs. 0.71). The Swedish
Knee Arthroplasty Register, in 2004, reported a 10-year follow-
up in over 30,000 patients, where secondary resurfacing was
compared with 3.8% for resurfaced. The same registry shows no differ-
ences regarding the type of resurfacing. Some authors totally remove the
articular cartilage layer, while some others leave the native one.

Patelloplasty

Patelloplasty consists of different procedures, such as patel-
lar decompression, lateral patellectomy, and patella reshaping,
which are aimed at creating a good congruence between the patella and femur. It has the advantage of
conforming to the articular facets of the patella toward a
large variability of tracking surfaces. In fact, the shape of the
trochlea could vary and the shape of the femoral prosthetic
component can vary as well according to the implant

Reshaping of the patella has the scope of achieving a good
matching between the prosthetic trochlea and the articular
surface of the patella. This procedure is conducted with or
without a resection of cartilage layer. Unfortunately, this is
not a well-standardized procedure. There are no specific and
worldwide-recognized steps of procedure. There is an exces-

Rate of complications is controversial due its variability in
procedures. Although this is a technique characterized by
rare intraoperative complications, there could be some
postoperative ones, such as maltracking for a new patellar
shape and a controversial adverse reduction of the strength
of the extensor mechanism; but this topic has not yet been
investigated in the literature.

The literature is still poor of relevant studies about this
issue. Sun et al. published a retrospective study with 152
patients, divided in two groups: patelloplasty versus denera-
tion. They found that patelloplasty was better in both
relieving AKP and improving patient’s satisfaction and
knee function. Župan et al. reported better clinical out-
comes in patients with patelloplasty with respect to the
simple denervation and removal of osteophytes. They found
better outcomes in Knee injury and Osteoarthritis Outcome
Score (KOOS) and in Oxford Knee Score, but revealed no
significant differences in KSS and pain scores. They also
correlated the results to postoperative patella thickness,
but they found no significant correlation. The first systematic
review focusing on patelloplasty in primary TKA has been
conducted by Ceriello et al. about clinical results, the
comparison between patelloplasty and simple denervation
and osteophytes removal revealed lower AKP in patelloplasty
(2.9% vs. 4.6%), as well better clinical outcomes at KOOS, KSS,
and Feller patellar score.

Though all these evidences show that patelloplasty is a
safe procedure without frequent intraoperative and post-
operative complication, the quality and quantity of studies
are still poor.

Control groups in the studies are often lacking. In some
other studies, preoperative data are missing, so comparisons
are extremely difficult.
Other Alternatives

Intraosseous hypertension is another important hypotheti-
cal cause of AKP in the third space after TKA. In degener-
ative pathologies of the knee, an increased intraosseous
pressure is described. This patellar hypertension, though
not specifically studied yet, is reported to be associated with
idiopathic AKP.

In several experimental studies, an impaired venous drai-

nag e a re linked with hypertension, especially in patients with
patellar chondromalacia and OA. Causes for an altered
venous drainage include direct compression of vascularization
from fat pad, osteophytes of the superior patella, a sustained
knee flexion position, chondromalacia, and OA.

Patellar drilling has been proposed for improving impaired

drainage and it could indirectly relieve AKP. The
first results described after decompression by drilling via the
infrapatellar fat pad reported a direct reduction of intraos-
sseous pressure and pain relief.

Ertürk et al. published a trial on 49 TKAs treated with
patelloplasty and decompression of the patella. They con-
ducted the decompression drilling on the edge of the patella
with the aim of not damaging the articular cartilage and
drilling at vertical plane to minimize the risk of fracture. The
authors reported excellent clinical results, especially for
range of motion (ROM) and patellar scores. Anyway, the
study did not use a control group.

Lee et al. compared patelloplasty to patelloplasty
decompression. A 3.5-mm drill has been used via fat pad
under tissue protection in the group with decompression.
The authors reported AKP in 21.3% of the control group and
in 18.5% of the study group. Higher KSS was observed in
patients with decompression (78.2 vs. 71.8).

Discussion

The incidence of AKP is high after TKA, reported between 4
and 49%. Daily activities are impaired due to this complica-
tion: they include stair climbing, cycling, and getting up from
a chair. Pathogenesis of AKP is still unclear but several
potential factors have been proposed to be linked.

Over time, the most studied options for the management
of this complication have been the treatments of patella
during a TKA.

The gross data reviewed in this article show that the
patella resurfacing might reduce pain but is associated to
severe complications. Moreover, some systematic reviews
and meta-analysis did not succeed in finding significant
differences in terms of clinical outcomes.

Unfortunately, patelloplasty is still poorly studied, even if
it seems the best alternative solution to resurfacing of the
patella. Systematic reviews and meta-analysis are affected by
poor quality of RCTs both in the methodology and in uni-

formity of samples of patients and outcomes.

RCTs are generally conducted through clinical and radio-
graphic evaluations, but few articles are available about bio-

mechanical performances. Smith et al. evaluated the gait
pattern by a meta-analysis, showing no significant differences
between resurfaced and un-resurfaced patellas. Myles et al.
used an electrogoniometer to evaluate improvements in ROM,
but they found no differences between the two groups of
patients.

Scientific literature lacks RCTs that focus on comparison
between patella resurfacing and patelloplasty. Campbell et al.76
found no significant differences in the International Knee
Society and Western Ontario and McMaster Universities
Osteoarthritis Index scores at 10-year follow-up. Similar
uncertain results have been reported by Burnett et al. However,
despite the clinical scores, patient’s preference was toward
resurfaced patella. Smith et al. evaluated 164 patients
through KSS, reoperation rate, AKP, and patient’s satisfaction.
No significant differences have been revealed, but a lower AKP
was reported for TKAs with resurfaced patella.

Several other elements have gained importance for the
assessment of the PFJ. Abnormal postoperative PF tracking
has been described as linked to retropatellar pressure.
However, some studies did not find a clear association
between patellar tilt or subluxation and AKP.

Generally, in the past, physicians believed that patellar
height was linked to AKP. Patella baja, although it has a poor
incidence in TKA, is surely a predisposing factor for flexion
deficit, but there are no studies that correlated this condition
to AKP. On the contrary, patella alta is generally associated
with higher contact forces between the trochlea and patella.
However, studies have not confirmed that it is a certain
predisposing factor for developing AKP.

van Houten et al. analyzed the effects of patella positioning on
AKP in TKA. The authors found that the amount of patellar displacement or
patellar tilt is not related to AKP.

Another critical aspect that is generally discussed is the
type of bearing surface of TKA. Fixed bearing has been always
believed to be of higher risk compared with mobile bearing
designs. Type of bearing surface might influence patellar
kinematics, because some studies showed lower PF contact
tress in the mobile bearing compared with fixed bearing.
However, few studies demonstrated a potential benefit of
mobile bearing in AKP, some of those suggested that the
performances of mobile bearing decline over time.

The tibiofemoral contact point is another potential predis-
posing factor for AKP. Greater anterior positioning of the tibio-

femoral contact point is the complication of the lever arm of the
tensor mechanism, which leads to PF disadvantage.

The last important element that is able to create a
variability in the onset of AKP is the vascular supply to the
patella. In fact, the amount of resection of fat pad can play an
important role.

Conclusion

The overall incidence of postoperative anterior knee in TKA is
still too high. Evidence-based publications cannot be easily
interpreted. There is statistical heterogeneity, perhaps
because of methodological diversity. The general trends
seem to present a reduction of risk of reoperation in TKA
with a resurfaced patella, but without significant benefits to
knee function and satisfaction with respect to patelloplasty.
So the decision of whether or not to resurface the patella should be assessed according to the evaluation of the PF joint, the design of the prosthesis, the experience of the surgeons, and patient’s features. Anyways, treatment of the patella does not seem to be the only factor that can influence ACP in TKA. Positioning of the femoral and tibial components, both in rotation and in AP direction, can influence the contact forces in the third space. The design of the prosthesis and choice of implant may also play an important role.

Treatment of smooth tissues is still poorly considered as a predisposing factor for ACP, such as the treatment of patellar fat pad, treatment of retinaculum, and balancing of peripheral compartments could be extremely important both for vascular supply of the extensor mechanism and for biomechanical tracking of the third space.

Conflict of Interest

None declared.

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