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## Common controversies in total knee replacement surgery: Current evidence

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### Abstract

Total knee replacement (TKR) is a widely used operation that has radically improved the quality of life of millions of people during the last few decades. However, some technical details, concerning the surgical procedure and the rehabilitation following total knee arthroplasty, are still a matter of a strong debate. In this review of the literature, we have included the best evidence available of the last decade, in an effort to shed light on some of the most controversial subjects related to TKR surgery. Posterior-stabilized or cruciate-retaining prosthesis? To use a tourniquet during operation or not? Do patients need continuous passive motion for their post-surgery rehabilitation? To resurface patella or not? These are some of the most controversial topics that until now have been persistent dilemmas for the orthopedic surgeon. Results of this systematic review of the literature are highly controversial. These conflicting results are an indication that larger and more well conducted high quality trials are needed in order to gain more secure answers. At the same time, it is becoming apparent that a meticulous operative technique, respecting the soft tissue envelope and knowing the principles of alignment and soft tissue balancing, are

some of the parameters that might contribute more to achieving the optimal results for the patients.

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**Key words:** Total knee replacement; Controversy; Literature review; Patella resurfacing; Patella eversion; Posterior stabilized; Cruciate retaining; Tourniquet; Continuous passive motion

**Core tip:** A literature review has been conducted in an effort to present the best available evidence of the last decade and to shed light on some of the most controversial subjects related to total knee replacement surgery. Patella resurfacing or not? Posterior cruciate retaining or sacrificing? Continuous passive motion or not? Tourniquet or not? These are some of the most debatable topics that until now have been persistent dilemmas for the orthopedic surgeon. Results of this systematic review of the literature are highly controversial. These conflicting results are an indication that larger and better conducted high quality trials are needed in order to gain more secure answers.

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### INTRODUCTION

Knee osteoarthritis (OA) is a very common condition with prevalence increasing with age. Recent studies estimated that the global burden of radiologically confirmed, symptomatic knee OA in 2010 was estimated to be 3.8%. This is a huge number, considering the world population, and it is expected to increase as the population ages<sup>[1]</sup>.

Total knee arthroplasty (TKA) is a widely used operation that has radically improved the quality of life of millions of people suffering from symptomatic knee OA during the last decades<sup>[2]</sup>. Studies have shown that TKA is one of the most common procedures performed during hospital stay, and according to the national registries, there is a continuously increasing number of operations performed worldwide each year<sup>[3]</sup>. It has been estimated that, by 2030, the demand for primary TKA is projected to increase to 3.4 million surgeries performed annually in the United States alone<sup>[4]</sup>.

Indeed, studies have shown that TKA is one of the most rewarding surgical procedures both for patients and surgeons<sup>[2]</sup>. However, other studies have shown that there is still a percentage of patients that remains dissatisfied with their clinical outcome<sup>[5-7]</sup>. As a result, there is an ever increasing effort in research and development in the field of knee arthroplasty aiming to improve patient safety and outcomes.

Several techniques have been described according to the patient's particular characteristics, and each of them has its own pros and cons, indications and contraindications. More specifically, some technical details, concerning the surgical procedure and the rehabilitation following TKA, are still a matter of a strong debate, despite the extensive investigations in the literature about their use. For example, the use of a posterior-stabilized or cruciate-retaining prosthesis, the necessity for a tourniquet and for continuous passive motion (CPM), the necessity for patella resurfacing or eversion during surgery, are some of the most controversial topics that until now have been persistent dilemmas for the orthopedic surgeon.

Thus, we tried to shed some light into these controversies, by extracting from the literature high quality papers that have as an object the answer to the previously reported questions.

An extensive search was conducted in MEDLINE (PubMed), Web of Science, and the Cochrane database for high quality. Prospective, randomized trials and meta-analyses. In order to be up-to-date and present the most recent findings, we preferred to include in our study only the papers published in the last decade. Initially, one reviewer conducted the literature search and retrieved the references for evaluation. A second reviewer independently selected the trials to be included in the review and also screened the reference lists of the selected articles in order to identify studies that were missed in the initial search.

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## POSTERIOR STABILIZED VS CRUCIATE RETAINING TKA

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Retaining the posterior cruciate ligament (PCL) or not still remains a matter of a strong controversy among the orthopedic surgeons. Numerous studies have yielded conflicting results. In this review, we were able to identify 8 relevant studies (6 prospective randomized trials and 2 meta-analyses).

The high quality papers that we collected began with the review of Jacobs *et al*<sup>[8]</sup> in 2005, who concluded that sacrificing the PCL leads to superior results concerning the range of knee motion, although they mention that the methodological quality of the studies that were included was highly variable and the results should be interpreted with caution. In 2008, Harato *et al*<sup>[9]</sup> performed a prospective randomized trial, with a minimum follow-up of 5 years, which confirmed the superiority of sacrificing the PCL (prosthesis Genesis II), for postoperative knee motion, but no significant difference was reported in knee function, postoperative complications and patient satisfaction. The randomized controlled trial by Chaudhary *et al*<sup>[10]</sup> also in 2008, is another study that finished with the conclusion that posterior-stabilized TKA does not have different outcomes with the posterior-retained one regarding pain, knee function, and quality of life scores. Furthermore, in contrast with the previously reported trials, the authors found that the range of knee motion 2 years after surgery was similar for the 2 kinds of TKA<sup>[10]</sup>. Kim *et al*<sup>[11]</sup> in 2009, in a prospective randomized study (minimum follow-up of 2 years), compared high-flexion posterior-retained with high-flexion posterior-stabilized prosthesis and also did not notice a difference in range of knee motion, clinical and radiographic results. However, in 2011, Seon *et al*<sup>[12]</sup> published another prospective randomized study which also compared high-flexion posterior-stabilized TKA with high-flexion posterior-retained TKA and disagreed: the former prosthesis proved superior to the latter in weight-bearing maximum flexion and posterior femoral roll-back, although no difference was noted in clinical outcomes. Yagishita *et al*<sup>[13]</sup> performed a prospective randomized study in 2012, with a minimum follow-up of 5 years, which indicated that posterior-stabilized prosthesis showed better results in postoperative knee motion, posterior knee pain at passive flexion and patient satisfaction, but no significant difference was found between the 2 types of TKA regarding Knee Society Score. On the other side, in 2012, Li *et al*<sup>[14]</sup> in a meta-analysis of randomized controlled trials, compared the 2 types of knee prosthesis and reported similar outcomes in postoperative knee pain, function, complications and prosthesis survivorship. Finally, the meta-analysis of randomized and quasi-randomized controlled trials by Verra *et al*<sup>[15]</sup> in 2013, confirmed that there was no difference between posterior-stabilized and posterior-retained TKA regarding pain, and clinical and radiological outcomes, despite the fact that the range of motion and Knee Society Score were found higher with the former type.

Thus, we can conclude that, generally, in the literature, neither the one nor the other prosthesis has been proved to offer clear clinical advantages. Nevertheless, we cannot neglect the fact that the studies that reported differences between the 2 types of TKA found superiority of posterior-stabilized knee prosthesis mainly with regard to range of motion (Table 1).

### ***Is it necessary to use a tourniquet?***

A strong debate is found in the literature about the

**Table 1 Studies comparing posterior cruciate retaining vs posterior cruciate sacrificing total knee replacement methods**

Ref.	Type of study	Outcome
Verra <i>et al</i> <sup>[15]</sup>	Meta-analysis of randomized and quasi-randomized controlled trials, comparing retention with sacrifice of the PCL in primary TKR	No clinically relevant differences found. Range of motion was 2.4° higher in the PCL sacrificing group
Li <i>et al</i> <sup>[14]</sup>	Meta-analysis of randomized controlled trials comparing posterior cruciate-retaining with posterior stabilized TKA	No differences between the 2 designs
Yagishita <i>et al</i> <sup>[13]</sup>	Prospective, randomized study comparing high-flexion CR design implanted in one knee and high-flexion PS design implanted in the other knee in simultaneous bilateral TKA	PS prosthesis better in postoperative knee motion, posterior knee pain at passive flexion and patient satisfaction
Seon <i>et al</i> <sup>[12]</sup>	Prospective randomized trial, comparing <i>in vivo</i> kinematics, range of motion, and functional outcomes in patients who received either a high-flexion cruciate retaining or a high-flexion cruciate substituting TKR	No differences in clinical outcomes. PS TKR superior to CR TKR in weight-bearing maximum flexion and posterior femoral roll-back
Kim <i>et al</i> <sup>[11]</sup>	Prospective randomized trial, comparing ROM and functional outcome in knees receiving either a high-flexion posterior cruciate-retaining or a high-flexion posterior cruciate-substituting TKR	No differences among groups
Chaudhary <i>et al</i> <sup>[10]</sup>	Prospective randomized study comparing range of motion of posterior CR vs posterior cruciate-substituting (PS) (TKA)	No differences among groups
Harato <i>et al</i> <sup>[9]</sup>	Prospective, randomized clinical trial comparing midterm outcomes of posterior CR vs posterior cruciate-substituting (PS) procedures using the Genesis II (TKA)	No significant difference in knee function, postoperative complications and patient satisfaction. Superior ROM in the PS group
Jacobs <i>et al</i> <sup>[8]</sup>	Systematic review and meta-analysis of prospective randomized trials	Range of motion 8° higher in the posterior-stabilized group compared to the PCL retention group

TKR: Total knee replacement; TKA: Total knee arthroplasty; PCL: Posterior cruciate ligament; PS: Posterior stabilized; CR: Cruciate retaining; ROM: Range of motion.

usefulness of the tourniquet in TKA. We were able to identify 11 studies (4 meta-analyses and 7 prospective randomized trials) which aimed to answer this question.

The high-quality papers that we found in the last decade began with the prospective randomized study by Ishii *et al*<sup>[6]</sup> in 2005 about the optimal time of tourniquet deflation in cementless TKA. The authors concluded that tourniquet release before wound closure caused a significant increase in total blood loss. Consequently, they recommended that the tourniquet should be released after wound closure and that a compressive dressing should be applied<sup>[6]</sup>. Moreover, on the same subject, a meta-analysis of randomized controlled trials by Rama *et al*<sup>[7]</sup> in 2007, indicated that early tourniquet release for hemostasis increases blood loss, but also decreases the risk of regional postoperative complications (wound complications, symptomatic deep venous thrombosis and knee stiffness requiring manipulation) and the risk of reoperation. The first high-quality study that we noted in the last decade concerning the dilemma about the use of a tourniquet or not is the prospective randomized trial of Li *et al*<sup>[18]</sup> in 2009. A tourniquet was not recommended because it caused significantly increased blood loss, lower free hemoglobin levels, more extensive postoperative swelling, and ecchymosis. Also, straight leg raising and knee flexion in the early period after surgery were negatively influenced by the use of a tourniquet, which, therefore, was clearly discouraged by the authors<sup>[18]</sup>. To strengthen this point of view, Smith *et al*<sup>[19]</sup> in 2010, with their meta-analysis and systematic review, concluded that the use of a tourniquet was combined with significantly greater incidence of pulmonary embolism, blisters, deep vein thrombosis, superficial wound healing disorders, hematoma, peroneal nerve palsy, and greater intraoperative blood loss, but no significant difference in total blood

loss. On the other hand, in 2012, we noted a randomized controlled trial by Tai *et al*<sup>[20]</sup>, which supported the use of a tourniquet. It was proved that it significantly reduced total blood loss, excessive postoperative inflammation, and muscle damage, but caused slightly more postoperative pain, which, nevertheless, did not affect postoperative recovery. Alcelik *et al*<sup>[21]</sup>, in a meta-analysis of randomized controlled trials in the same year, agreed that the use of a tourniquet restricted total blood loss, but was accompanied by a significantly higher rate of minor complications and did not affect the time of surgery and the incidence of thromboembolism. However, Ledin *et al*<sup>[22]</sup> in their randomized study, also in 2012, were not in favor of the use of a tourniquet, claiming that it did not improve the fixation of the components of TKA (as was indicated by the measurement of their migration with radiostereometric analysis), increased postoperative pain, and reduced the range of knee motion (the follow-up was up to 2 years after surgery). Additionally, in 2012, Mittal *et al*<sup>[23]</sup> performed a randomized controlled trial to investigate the possible advantages of tourniquet application only during cement fixation: the authors noted a significantly higher risk of transfusion and no functional benefit up to 1 year after surgery and, therefore, did not present restricted application of a tourniquet around the cement fixation as the optimal solution. Another interesting randomized controlled trial in 2012, by Olivecrona *et al*<sup>[24]</sup>, demonstrated that measuring the limb-occlusion pressure before surgery reduced cuff pressure during surgery without influencing the quality of the bloodless field. Furthermore, the authors did not note differences in the parameters of postoperative pain, knee motion, and wound-related complications between the groups and came to an important secondary finding: in patients with a cuff pressure less than 225 mmHg, there were no postoperative infections and a lower rate

**Table 2** Studies investigating the usefulness of tourniquet use in total knee replacement

Ref.	Type of study	Outcome
Molt <i>et al</i> <sup>[27]</sup>	Prospective randomized controlled trial. To use a tourniquet or not. To evaluate the early migration, measured by RSA, of cemented knee prosthesis	No differences between the groups regarding the translation or rotation of the components as measured by RSA
Tarwala <i>et al</i> <sup>[26]</sup>	Randomized trial. To use a tourniquet only during cementation or up to wound closure	No differences in surgical time, pain scores, pain medicine requirements, range of motion, hemoglobin change, or total blood loss
Li <i>et al</i> <sup>[25]</sup>	Meta-analysis of randomized controlled trials. To use a tourniquet or not	Tourniquet effective for reducing intraoperative blood loss but not for reducing the postoperative blood loss and total blood loss
Olivecrona <i>et al</i> <sup>[24]</sup>	Randomized controlled trial. Tourniquet cuff pressure based on the patient's systolic blood pressure or based on the measurement of the limb occlusion pressure	No differences between the groups regarding postoperative pain or complications. Tourniquet cuff pressure based on measurement of the limb occlusion pressure had less wound complications
Mittal <i>et al</i> <sup>[23]</sup>	Double-blind, randomized controlled trial. Tourniquet application only during cement fixation or continually	Higher risk of transfusion in the short tourniquet use group. No difference in the Oxford knee score or rate of recovery
Ledin <i>et al</i> <sup>[22]</sup>	Randomized trial of cemented TKR. To use a tourniquet or not	Tourniquet increased postoperative pain and reduced the range of knee motion. Tourniquet group had less overt bleeding
Alcelik <i>et al</i> <sup>[21]</sup>	Systematic review and meta-analysis of selected randomized controlled trials. To use a tourniquet or not	Tourniquet restricted total blood loss, but was accompanied with significantly higher rate of minor complications
Tai <i>et al</i> <sup>[20]</sup>	Prospective randomized trial. To use a tourniquet or not	Tourniquet effectively reduced blood and avoided excessive postoperative inflammation and muscle damage. Tourniquet group had slightly more post-op pain
Smith <i>et al</i> <sup>[19]</sup>	Meta-analysis of randomized and non-randomized trials. Tourniquet use or not	No advantage to using a tourniquet in knee replacement surgery for reduction of transfusion requirements
Rama <i>et al</i> <sup>[17]</sup>	Meta-analysis of randomized trials. Tourniquet release either before or after wound closure	Tourniquet release before wound closure increases the blood loss. However, tourniquet release after wound closure can increase the risk of early postoperative complications requiring another operation
Ishii <i>et al</i> <sup>[16]</sup>	Randomized trial in patients who had undergone cementless TKA. Tourniquet release either before or after wound closure	Tourniquet release before wound closure caused a significant increase in total blood loss

RSA: Radiostereometric analysis.

of wound complications<sup>[24]</sup>.

In 2013, Li *et al*<sup>[25]</sup> performed a meta-analysis of randomized controlled trials and concluded that the use of a tourniquet significantly decreased the intraoperative blood loss but did not influence total blood loss. Besides, patients with a tourniquet did not have neither a higher risk of thromboembolic complications nor significant difference in the time of surgery compared with patients without a tourniquet<sup>[25]</sup>. Also, in 2013, Tarwala *et al*<sup>[26]</sup> in a randomized trial, examined the outcomes of the use of a tourniquet only during cementation and found that it offered bloodless bone for fixation, and did not influence the surgical time, pain, range of knee motion and total blood loss. Consequently, they recommended this method, claiming that it may restrict the possible risks related to prolonged tourniquet use<sup>[26]</sup>. Finally, the prospective randomized study by Molt *et al*<sup>[27]</sup> in 2013, underlined that tourniquet use did not affect the stability of the tibial tray of cemented TKA in a 2-year follow-up, as was demonstrated by a radiostereometric analysis.

In conclusion, we can see that the answer to the complicated dilemma “tourniquet or not?” is still difficult despite the extensive research on this subject. It is evident that several questions emerge about tourniquet use, related, for example, to the optimal timing of its release, the ideal cuff pressure, and the stages of surgery in which it should be inflated. Thus, further research is required to clarify these ambiguous aspects of tourniquet use and to construct definite guidelines. Table 2 summarizes the findings of the previous studies.

## CPM: TO USE OR NOT TO USE?

We were able to identify 11 studies (3 meta-analyses and 7 prospective randomized trials) investigating the usefulness of CPM post TKR surgery.

The meta-analysis of Brosseau *et al*<sup>[28]</sup> in 2004 is the first high quality study that we noted in the last decade, concerning the question about the use of CPM. The authors concluded that there was a significant improvement in active knee flexion and analgesic use up to 2 wk postoperatively, while the average hospital stay was decreased, as was the need for knee manipulations under anesthesia<sup>[28]</sup>. However, the authors also highlighted the need for further research about the use of CPM, because of its inconvenience and expense, and put the question about the determination of protocols concerning the duration and intensity of CPM application<sup>[28]</sup>. Following this study, Leach *et al*<sup>[29]</sup> in 2006 published a prospective randomized trial, with a 1-year follow-up, in which they concluded that CPM does not offer significant benefits in range of knee motion and pain, after the application of a specific CPM protocol. This publication initiated a series of high-quality studies, which, since then, have contested the use of CPM after TKA. More specifically, in 2007, Postel *et al*<sup>[30]</sup> in their review of level I and II studies, noted that CPM offered short-term benefits concerning postoperative pain, swelling and knee motion, but claimed that long-term benefits were not established, and underlined the necessity for investigation of different CPM modalities and comparison with alternative intermittent mobiliza-

**Table 3** Studies investigating the usefulness of continuous passive motion after total knee replacement

Ref.	Type of study	Outcome
Maniar <i>et al</i> <sup>[35]</sup>	Prospective randomized trial. To use or not to use continuous passive motion post TKR	No benefit from CPM use in immediate functional recovery post-TKR and postoperative ROM. The postoperative knee swelling persisted longer in the CPM group
He <i>et al</i> <sup>[34]</sup>	Meta-analysis of randomized trials (Cochrane). CPM or not against VTE	No evidence that CPM reduces VTE after TKR
Harvey <i>et al</i> <sup>[33]</sup>	Meta-analysis of randomized trials (Cohrane). CPM use or not	CPM increases passive knee flexion ROM by mean 2 degrees and active knee flexion ROM by mean 3 degrees. This effect is too small to clinically justify the use of CPM. Weak evidence that CPM reduces the need for manipulation under anesthesia
Alkire <i>et al</i> <sup>[32]</sup>	Prospective randomized study. CPM use or not for computer-assisted TKA	No statistically significant difference in flexion, edema or drainage, function, or pain between groups 3 mo post-surgery
Lensenn <i>et al</i> <sup>[31]</sup>	Randomised controlled trial. Effectiveness of prolonged CPM use <i>vs</i> in hospital only use of CPM	No long term difference in ROM or any of the outcome assessments
Leach <i>et al</i> <sup>[29]</sup>	Prospective randomized trial investigating the effect of CPM on range of knee flexion, lack of extension, pain levels and analgesic use after TKR	No differences among studied groups
Brosseau <i>et al</i> <sup>[28]</sup>	Meta-analysis of studies examining the effectiveness of CPM	Significant improvement in active knee flexion and analgesic use 2 wk postoperatively with the use of CPM and PT compared with PT alone

CPM: Continuous passive motion; VTE: Venous thromboembolism; PT: Physiotherapy; TKR: Total Knee replacement; ROM: Range of motion.

tion techniques for safer conclusions. Moreover, in 2008, Lensenn *et al*<sup>[31]</sup> in a randomized controlled trial, came to agree that CPM improved short-term range of knee motion but they did not recommend its prolonged use as an adjunct to physiotherapy, because their long-term results did not confirm their initial conclusion. To the previously mentioned papers, which were about conventional TKA, Alkire *et al*<sup>[32]</sup> added a prospective randomized trial in 2010 which examined the effectiveness of the use of CPM in computer-assisted TKA: they concluded that CPM did not offer any significant benefit concerning the range of knee motion, pain, swelling, and knee function<sup>[32]</sup>. Additionally, the use of CPM was discouraged by the review of randomized controlled trials by Harvey *et al*<sup>[33]</sup> also in 2010, who supported that, in the patients who participated, range of knee motion, pain, swelling, quadriceps strength, length of hospital stay, and incidence of manipulation under anesthesia, did not show significant improvement after the use of CPM<sup>[33]</sup>. Another interesting parameter of the possible effectiveness of CPM was investigated by He *et al*<sup>[34]</sup> with their review of randomized controlled trials concerning the possible prevention of venous thromboembolism. They claimed that CPM did not significantly reduce this risk. Finally, Maniar *et al*<sup>[35]</sup> in a prospective randomized trial in 2012, further discouraged the use of CPM after TKA, supporting that it not only did not significantly improve immediate functional recovery, but also had a negative impact on postoperative swelling.

From the previously reported data, we can conclude that there is no recent high-quality published study that is in favor of the use of CPM during rehabilitation after TKA and, therefore, remaining extensive use of routine CPM should probably be reconsidered (Table 3).

## PATELLA RESURFACING OR NOT?

Patellar resurfacing during TKA is another subject about

which orthopedic surgeons express different points of view and is a matter of long-standing debate. We were able to identify 10 studies (5 prospective randomized trials and 5 meta-analyses), aiming to answer the question of resurfacing the patella or not.

In 2007, Burnett *et al*<sup>[36]</sup> performed a prospective randomized trial with a minimum follow-up of 10 years and noted similar results for patellar resurfacing and nonresurfacing regarding the patient's pain, satisfaction, knee motion, and revision rate. A few years later, Burnett *et al*<sup>[37]</sup> in 2009, published the updated data from the previous randomized trial. Results confirmed the previously reported findings for the same parameters. A well conducted systematic review of the literature, which reported significant advantages of patellar resurfacing, was published by Calvisi *et al*<sup>[38]</sup> and merits mention. The authors concluded that this procedure reduced the risk of anterior knee pain, pain during stair climbing, and the patella-related reoperation rate, while increasing patient satisfaction and did not significantly influence knee motion<sup>[38]</sup>. However, they were not clearly in favor of the method of patellar resurfacing<sup>[38]</sup>. More recently, in 2011, Breeman *et al*<sup>[39]</sup> in a randomized controlled trial with a 5-year follow-up, found that this method did not have a significant impact on functional outcomes, reoperation rate, and total healthcare cost. Also in 2011, Pavlou *et al*<sup>[40]</sup> expressed the same opinion by performing a meta-analysis which indicated that patellar resurfacing did not significantly affect anterior knee pain and functional outcomes. The authors noted more reoperations in the non-resurfacing group, but they considered this result as possibly artificial, because secondary patellar resurfacing offers a surgical option for the therapy of anterior knee pain<sup>[40]</sup>. Furthermore, Fu *et al*<sup>[41]</sup> in 2011 published a meta-analysis in which they did not support patellar resurfacing as a matter of routine, as they did not notice a marked advantage, although they did note that this method reduced the

**Table 4 Patella resurfacing vs non-resurfacing in primary total knee replacement**

Ref.	Type of study	Outcome
Chen <i>et al</i> <sup>[48]</sup>	Meta-analysis of randomized controlled trials Patellar resurfacing vs nonresurfacing in primary TKR	Patellar resurfacing reduces the risk of reoperation after TKR. No difference between the 2 groups in terms of anterior knee pain, knee pain score, Knee Society score and knee function score
Pilling <i>et al</i> <sup>[44]</sup>	Meta-analysis of randomized controlled trials. Patellar resurfacing vs nonresurfacing in primary TKR	The reoperation rate due to anterior knee pain, and the patella-femoral complication rate was significantly higher in the resurfacing group. The knee component of the Knee Society Score was higher in the resurfacing group. No significant difference was observed for the function component of the Knee Society Score or for any other reported knee score
Beaupre <i>et al</i> <sup>[43]</sup>	Randomized controlled trial. Patellar retention vs patellar resurfacing in primary TKR	No differences among the studied groups
Liu <i>et al</i> <sup>[46]</sup>	Randomized prospective trial. Patellar reshaping vs resurfacing in TKR	No significant differences between the 2 groups in terms of total Knee Society score, Knee Society pain score, Knee Society function score and anterior knee pain rate
Fu <i>et al</i> <sup>[24]</sup>	Meta-analysis of randomized controlled trials. Patellar resurfacing vs nonresurfacing	Patellar resurfacing reduce the risk of reoperation after TKR. No difference in anterior knee pain
Breeman <i>et al</i> <sup>[39]</sup>	Multicenter, randomized controlled trial. Patellar resurfacing or not	No significant difference between the 2 groups regarding functional outcome, reoperation rate, and total health care cost at 5 yr post TKR
Pavlou <i>et al</i> <sup>[40]</sup>	Meta-analysis of Level-I randomized controlled trials. Patellar resurfacing or not	No significant differences between groups with regard to the incidence of anterior knee pain. Higher rate of reoperations was observed in the non-resurfacing group
He <i>et al</i> <sup>[34]</sup>	Meta-analysis of randomized trials. Patellar resurfacing or not	Reoperation for patella-femoral problems significantly more likely in the nonresurfacing group. No difference between the 2 groups in terms of anterior knee pain rate, knee pain score, knee society score and knee function score
Burnett <i>et al</i> <sup>[37]</sup>	Prospective randomized trial. Patella resurfacing vs nonresurfacing in patients undergoing bilateral TKA	No differences regarding the studied parameters
Burnett <i>et al</i> <sup>[36]</sup>	Prospective randomized trial. Patella resurfacing vs nonresurfacing in patients undergoing bilateral TKA	No differences with regard to range of motion, Knee Score, satisfaction, revision rates, or anterior knee pain

TKR: Total knee replacement; TKA: Total knee arthroplasty.

risk of reoperation. Additionally, Li *et al*<sup>[42]</sup> also in 2011, in a meta-analysis of randomized controlled trials, reported that, despite the fact that the risk for reoperation due to patella-femoral problems was significantly reduced by patellar resurfacing, there was no difference in pain and knee function. Beaupre *et al*<sup>[43]</sup> in 2012, performed a randomized controlled trial, with a follow-up of 5-10 years, in which they agreed that patellar resurfacing showed no difference with non-resurfacing regarding knee specific outcomes, like pain, stiffness, and function. Also in 2012, Pilling *et al*<sup>[44]</sup> in a meta-analysis of randomized controlled trials, highlighted the advantages of this method in the field of preventing additional surgical procedures and patella-femoral complications, but, nevertheless, reported no difference in operative time, infection rate, radiographic appearance, patient satisfaction, and anterior knee pain.

Of note, Altay *et al*<sup>[45]</sup> in 2012, investigated the subject of patellar denervation only, without patellar resurfacing: their prospective randomized study demonstrated that patellar denervation could significantly restrict anterior knee pain with satisfactory clinical and radiological outcomes, without patellar resurfacing<sup>[45]</sup>. Another alternative solution was presented by Liu *et al*<sup>[46]</sup> in a prospective randomized trial in the same year, compared patellar resurfacing with patellar reshaping, *i.e.*, removing the partial lateral aspect of the patella and the surrounding osteophytes and trimming the patella to match the trochlea of the femoral component. In a minimum follow-up

of 7 years, the authors did not find a difference between the 2 methods regarding pain, radiographic findings, and functional knee scores, but recommended patellar reshaping, because it retained sufficient patellar bone stock and could easily be converted to patellar replacement in the case of recurrent anterior knee pain<sup>[46]</sup>.

In 2013, the randomized controlled trial by Pulavarti *et al*<sup>[47]</sup> shed more light on the subject of patellar denervation without resurfacing: the method appeared safe, and improved patient satisfaction and range of knee flexion but did not ameliorate validated knee scores in a follow-up of 2 years<sup>[45]</sup>. Finally, Chen *et al*<sup>[48]</sup> also in 2013, published a meta-analysis of randomized controlled trials which supported the point of view that patellar resurfacing reduced the risk of reoperation and, moreover, gave better results in Knee Society Score in a follow-up of 5 years or more, but the overall benefits of the method were not sufficient to convince the authors to prefer this method over patellar non-resurfacing<sup>[48]</sup>.

In conclusion, it is clear that patellar resurfacing as a common practice is not supported enough by the high-quality trials of the last decade, although some benefits have been adequately documented. More specifically, current evidence tends to suggest that patellar resurfacing may reduce the reoperation rate due to patello-femoral problems. Several alternative methods have been recommended with promising results, but future research will further clarify whether the advantages of patellar resurfacing are strong enough to encourage its use among the

Table 5 Patellar eversion *vs* subluxation

Ref.	Type of study	Outcome
Umrani <i>et al</i> <sup>[52]</sup>	Prospective randomized trial. Patellar eversion or not (mid-vastus approach)	No statistical differences between 2 groups throughout the follow-up periods in recovery of quadriceps force or power and clinical data
Arnout <i>et al</i> <sup>[51]</sup>	Prospective randomized study. Medial parapatellar arthrotomy with patellar eversion <i>vs</i> same approach without eversion	Patellar dislocation without eversion improved range of motion at 1 yr postoperatively. All other studied parameters were not significantly different
Dalury <i>et al</i> <sup>[50]</sup>	Prospective randomized trial. Patellar eversion and anterior tibial translation <i>vs</i> patellar subluxation and no tibial translation	No significant differences between the treatment groups at 6 wk, 12 wk or 6 mo after surgery
Walter <i>et al</i> <sup>[49]</sup>	Prospective, randomized, blinded study. Mid-vastus split with or without patellar eversion <i>vs</i> median parapatellar arthrotomy or a mid-vastus split both without patellar eversion	Significantly earlier return of straight leg raise was noted when patellar eversion was avoided
Reid <i>et al</i> <sup>[53]</sup>	Prospective randomized double-blinded study. Patients undergoing TKA through a standard medial parapatellar approach assigned to either retraction or eversion of the patella groups	No significant clinical differences in the early to medium term. With patella retraction, there may be an increased risk of damage to the patellar tendon and increased risk in implant malpositioning

orthopedic community (Table 4).

## PATELLAR EVERSION OR NOT?

Patellar eversion during TKR surgery has traditionally been used to facilitate exposure and component positioning. More recently, the theory that avoiding patella eversion results in better range of motion and earlier quadriceps recovery has gained popularity. However, controversy regarding this technique still exists. Few high-quality trials (more specifically, 5 prospective randomized studies) have been published in the literature during the last decade concerning the usefulness of patellar eversion in TKA. Initially, in 2007, Walter *et al*<sup>[49]</sup> performed a study which led them to the conclusion that avoiding patellar eversion led to earlier return of quadriceps function and a decrease in the length of patient stay in hospital. On the other hand, in 2009, Dalury *et al*<sup>[50]</sup> claimed that patellar eversion and anterior tibial translation showed no significant difference to patellar subluxation and avoiding tibial translation on range of knee motion, quadriceps strength and patient's knee preference, up to 6 mo after surgery. Furthermore, Arnout *et al*<sup>[51]</sup> in 2009, in a prospective randomized study, concluded that patellar dislocation without eversion improved the active and passive range of knee motion up to 1 year postoperatively and recommended this procedure as safe. Umrani *et al*<sup>[52]</sup> in 2013, found that patellar eversion did not significantly affect quadriceps recovery after TKA up to 1 year after surgery. In the most recent study, Reid *et al*<sup>[53]</sup> in 2014 found that patients who underwent TKR with patella eversion had similar clinical outcome 3 mo and 1 year postoperatively with patients who had TKR with patellar subluxation. They also noted that patellar subluxation may lead to an increased risk of damage to the patella tendon and increase in tibial component malpositioning.

As a conclusion, we could say that the available evidence is not strong enough to support either patellar eversion or subluxation, as a standard technique during TKR surgery. More high-quality trials need to be performed for stronger evidence. Table 5 summarizes the

available evidence.

## CONCLUSION

Results of this review of the literature are highly controversial. We have tried to extract the best and most up-to-date evidence available regarding some of the most debatable aspects of TKR surgery regarding the everyday surgical technique of thousands of orthopedic surgeons around the world. These conflicting results indicate that larger and more well conducted high quality trials are needed in order to gain more secure evidence. At the same time, it is apparent that, irrespective of the variations in the operative techniques, certain parameters may contribute more to long-term successful results after TKR surgery. A meticulous operative technique, respecting the soft tissue envelope, and knowing the principles of alignment and soft tissue balancing are some of the parameters that may be of major relevance in achieving optimal results for TKA patients.

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