Isolated Patellofemoral Arthroplasty-Surgical Technique and Tips: Current Concepts

Dr. Jobe Shatrov MBBS (Hons), FRACS, FAOrthoA, Bsc. (Physio), Grad. Dip. (Surgical Anatomy)  
Sydney Orthopaedic Research Institute (SORI) at Landmark Orthopaedics, St. Leonards, Sydney  
admin@drjobeshatrov.com

Dr Myles RJ. Coolican*  
MBBS, FRACS, FAOrthA, Sydney Orthopaedic Research Institute (SORI) at Landmark Orthopaedics, St. Leonards, Sydney  
myles@mylescoolican.com.au

Cell phone: +61 417 222 600  
Office: + 61 2 9904 6099
Abstract
Successful patellofemoral arthroplasty (PFA) requires appropriate patient selection, correct implant positioning and attention to surgical technique. Whilst the original concept and rationale offered an attractive surgical option for patients with isolated patellofemoral arthritis, early results were disappointing and consequently many surgeons became reluctant to offer it. With newer generation design, outcomes have been more promising. However, attention to surgical technique remains an integral component to a successful outcome, with results being unforgiving when surgical errors are made. This paper explores the key components of the surgical technique in PFA, including implant design, patient selection and tips to avoid common mistakes.

Keywords: patellofemoral arthroplasty, patellofemoral replacement, isolated patellofemoral replacement, patellofemoral technique, patellofemoral prosthesis

Funding: This paper did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Current Concept
- Patellofemoral arthroplasty implant design has evolved significantly since its early use with modern designs demonstrating improved survival rates on implant registry’s
- Careful patient selection remains critical to achieving a good outcome
- A successful surgical technique requires the surgeon to place appropriately sized components in relation to well described anatomical landmarks in such a fashion as to ensure a smooth motion of the patella through an arc of flexion, free of any incongruity

Future Perspective
- Robotically-assisted patellofemoral arthroplasty may allow for more precise implant positioning, however more research is required to determine if will translate into improved clinical outcomes
- Computer-assisted patella tracking remains an unsolved challenge in knee arthroplasty
- Integration of artificial intelligence may assist in patient selection in the future

Introduction
The ground-breaking work of Blazina and others describing isolated replacement of the patellofemoral joint published in 1979 [1] was the first series reporting the outcomes of patients who had undergone resurfacing of the patellofemoral articulation. Since this time, implant design has undergone several generations of evolution and the significance of a meticulous attention to surgical technique and patient selection has become appreciated. Now, it is clearly understood that the key to achieving successful patellofemoral arthroplasty (PFA) is a combination of appropriate patient selection, correct implant positioning and attention to surgical technique.

Indications

Implant Selection
- Patellofemoral arthroplasty implant design has evolved significantly since its early use with modern designs demonstrating improved survival rates on implant registry’s
Implant selection is one factor that has been shown to affect survival rates and also the need for re-operation. Early design prostheses showed poor longevity and results inferior to that of total knee arthroplasty (TKA) [2-7]. In a recent meta-analysis, the likelihood of any re-operation (odds ratio (OR) 8.06) and revision (OR 8.11) in PFA compared to TKA was compared. When comparing second generation PFA to TKA, there was no significant difference in re-operation, revision, pain, or mechanical complication rates [8].

First generation patellofemoral implants required freehand preparation of the bony surfaces, which were often already deformed prior to surgery as a consequence of trochlear dysplasia. This made correct implant position difficult to determine and could result in malalignment of the trochlear component. Second generation implants similarly were reported to not offer an appropriate means to prepare the distal femur and allow a smooth junction of the distal end of the trochlear component to the native femur. Improvements in the newer generation implants include a more anatomical design and jigging systems so that the implant more easily matches the articular surface and has a smooth transition particularly in the zone of flexion distally. The new systems include instrumentation to ensure this smooth transition by accurately milling the bone to the correct depth and also provide an effective means for addressing the large variations seen in the intercondylar region. Such accuracy is in stark contrast to the freehand techniques of the earlier systems [9, 10]. Earlier systems also included inlay trochlea components which were much smaller than modern designs and covered less than a half of the trochlea leaving native bone and cartilage exposed.

The results of newer generation designs such as the Avon patellofemoral replacement (Stryker Orthopaedics, Kalamazoo, Michigan), which was introduced in 1996 have been more promising with a survivorship of 95.6% at an average five year follow up being reported. The same series also reported that 85% rated the result as good or excellent but 12% reported the sensation of clicking at approximately 40° of flexion[11]. **Examples of newer generation prosthesis design are shown in figure 1.**

**Patient Selection and Preparation**

- Appropriate patient selection is critical to a successful outcome – always obtain consent from the patient to proceed to a total knee arthroplasty in anticipation of finding that the joint is not suitable for receiving an isolated PFA after performing the arthrotomy

The ideal patient is 60 and above, with severe disability secondary to patellofemoral osteoarthritis (PFOA) with trochlear dysplasia that is typically on the lateral side, severe Iwano III or IV PFOA with a body mass index (BMI) in the normal range (<30) and a tibiofemoral articulation that is preserved[12]. Patient selection may be aided by the addition of a pre-operative technetium bone scan rather than MRI alone, with one study reporting 100% survivorship following PFA when patients were selected using a preoperative bone scan compared to a 31% revision rate when MRI scans were used in the surgical workup [13]. Patient expectations need to be realistic and similar to the constraints placed after TKA. Whilst there are rare examples of patients being to perform high level activities including sport after PFA, these are considered the exception and not the rule.

The usual steps taken prior to TKA to ensure the patient is fit for surgery remain appropriate for PFA. However, there should be added emphasis prior to surgery on the restoration of quadriceps strength and endurance. Arthrogenic muscle inhibition (AMI) is well known to be a cause of slower recovery and poorer outcomes following knee surgery (7). Quadriceps dysfunction has previously been associated with ACL re-rupture[14] and poor long-term recovery following surgery[15]. Patients with isolated patellofemoral arthritis are particularly prone to develop AMI after often a lifetime of quadriceps
avoidance behavior. Those with longstanding patellofemoral arthritis walk for many years with a quadriceps sparing gait denying their quadriceps a workout with every step.

Surgical Approach

Whilst patient selection remains possibly the most important ingredient to successful isolated replacement of the patellofemoral joint, the role of correct surgical technique cannot be overstated. There is no doubt that a poorly executed operation in a correctly selected patient will require revision earlier than if the implant is properly inserted.

Most surgeons are comfortable with patellar resurfacing and perform this either selectively or routinely with total knee arthroplasty (TKA) but may be unfamiliar with preparation for inserting the trochlear component. Isolated PFA is performed with a shorter incision that preserves structures such as the anterior horn of the medial meniscus that is ordinarily divided during exposure for TKA. However, the surgeon needs sufficient exposure to be able to locate the landmarks to correctly position the implants and achieve a construct where the patella tracks smoothly across the junction of the distal end of the trochlear implant and the native femur. There is near complete agreement that modern implant systems allow this to occur more successfully than was the case for the first generation on implants and it is likely that these improvements along with refinements in patient selection have greatly improved outcomes and reduced revision rates with PFA.

The patient is placed in a supine position with or without an above knee tourniquet. A foot bolster is placed to position the leg at 90 degrees of knee flexion with a side support. A combination of sedation and spinal anaesthesia is the preferred anaesthetic in order to facilitate early post-operative mobility. Intraoperatively, sub periosteal infiltration of a cocktail containing local anaesthetic, adrenaline, ketorolac and clonidine is utilised for analgesia. We do not use nerve blocks that could impair quadriceps function and delay mobilising on the day of surgery.

Surgical Exposure

- Avoid a lateral release at all costs if a medial arthrotomy has been performed due to the risk of avascular necrosis and patella fracture
- If a lateral release is considered likely due to excessive tightness and pre operative lateral tilt, a lateral arthrotomy should be considered

Surgical exposure should allow the twin goals of locating the necessary landmarks to allow for PFA whilst avoiding any damage to other intra-articular knee structures. Whilst a standard midline incision is commonly utilised for the approach, a lateralised skin incision can be performed when a lateral release is planned. Laterally based skin incisions carry the additional benefit of reducing the size of the numb area associated with infrapatellar branch of saphenous nerve division as well as reducing sensitivity with kneeling. Whilst any superiority of a medial versus lateral approach has not been shown in the literature, a lateral incision has been associated with a reduction in post-operative patellar tilt [16, 17]. Additionally, a medial approach has also been shown to compromise patella vascularity by damaging the supreme, superior medial and inferomedial genicular arteries[18]. Patellar vascularity can then be further compromised if a lateral release is required. Patellar osteonecrosis has been reported following the use of lateral releases[19] which may be avoided by utilising a lateral parapatellar incision as originally described by Keblish in TKA with fixed valgus deformity[20]. Furthermore, a lateral
approach preserves the medial stabilising structures and allows for offset capsular and synovial incisions - the Z approach- which may be desirable in patients with pre-existing patellar tilt as described by Ammari et al[21] and will result in reduced sensory loss [22].

Despite these proposed advantages, the literature has shown no significant difference in the results for patients who have undergone patellofemoral arthroplasty using these two approaches [16]. Furthermore, the lateral approach is considered more demanding as most surgeons are less familiar with it as a technique for performing knee arthroplasty. It is important to recall that evertting the patella medially reverses the usual position of the medial patellar facet which must be born in mind when the patella is cut or milled. Our preference is to utilise a standard medial parapatellar approach with lateral eversion of the patella which carries the benefit of familiarity with the bony landmarks. Regardless of the chosen approach, care must be taken when performing the arthrotomy so as to avoid damage to the meniscus, the inter-meniscal ligament, the anterior cruciate ligament and the articular cartilage of the femur and tibia.

Once the exposure has been performed, a thorough assessment of the entire knee is carried out. Attention should be paid to the extent of degenerative changes particularly bone stock loss in the patellofemoral joint. Additional inspection of the medial and lateral compartments is also undertaken noting the state of the articular cartilage and the menisci, as one would do during an arthroscopy. The integrity of the anterior cruciate ligament is also assessed.

Landmarks-Femur

The femoral anatomical landmarks are drawn with a marking pen to position the trochlea implant in neutral rotation. Two landmarks have been described and can be used in combination to achieve a neutral rotation[23, 24];

Whitesides line; Whitesides line is drawn using a surgical marking pen from the centre of the proximal trochlea to the central apex of the intercondylar notch. The anterior trochlear cut is then made perpendicular to Whitesides line. Cartilage wear and trochlea dysplasia may obscure this alignment.

The surgical transepicondylar axis; the cut is made parallel to the surgical transepicondylar line which is drawn across the distal femur with a marking pen. Both epicondyles are located and the points transposed distally to the articular surfaces. The centre of the medial epicondyle sulcus is utilised-this has been described by some surgeons as having a sensation of being in the centre of a doughnut. The bony prominence of the lateral epicondyle is often more easily palpated and transposed distally to the articular surface. Both may be difficult to palpate in cases of recurrent patellar instability where dislocation may have distorted the anatomy. The reproducibility of this landmark in arthroplasty has been debated.

Anatomical axis of the femur;

The trochlea groove should align closely with the anatomical axis of the femur and is a useful guide for ensuring the varus/valgus alignment of the prosthesis is correct [25] (figure 2). By positioning the implant in line with the patient’s own “trochlear” axis, it is more likely to result in a flush position on both sides of the component – as it interfaces with the patient’s chondral surfaces.

Landmarks-Patella

Patients undergoing isolated PFA frequently have more patellar wear than those undergoing TKA for tibiofemoral wear. The typical unworn patella has a thickness of somewhere between 22 and 28mm whilst a severely worn patella with trochlear dysplasia may have a maximal thickness of under 20 mm
with the lateral facet being worn to a thickness of 10mm or less. In this setting, it is important to remember the usual surgical goal to achieve a flat cut or milled surface which parallels or is close to parallel with the anterior surface may be compromised. Bone stock loss frequently means excess bone would be removed medially if the entire surface is to be flat, leaving an abnormally thin patella which is prone to fracture. Our practice is to restrict the residual patellar thickness to 14 mm or more which results in two surfaces-the milled or cut medial part and the sclerotic lateral facet. Whilst drilling the sclerotic component to enhance fixation akin to what can be done for a sclerotic tibial or femoral cut surface is possible, we avoid this to minimize the prospect of “postage stamping” the patella with subsequent fracture. The resulting defect is generally less than 3-4 mm and is filled with bone cement.

**Trochlea Preparation**

- The critical goal of femoral component placement is to ensure a smooth transition of the patella through an arc of flexion – avoid incongruity between the trochlear articular cartilage and the implant.

Each proprietary design for patellofemoral arthroplasty has specific instrumentation to perform bone resection and aid in implant positioning. The technique guide that applies to each system should be referred to in preparation for performing the surgery. The goal is to place the implant in the correct position remembering there are six degrees of freedom.

**Anterior Cut**

Most patellofemoral arthroplasty implants are of an onlay design. This requires the implant to be placed flush with the anterior cortex of the femur (19) with the anterior trochlear resection guide being used to achieve this goal and avoid damage to the anterior cortex. Most systems use an intramedullary rod and stylus to achieve this outcome (**figure 3**). The anterior cut will eliminate any trochlear dysplasia and determines rotation of the component in the axial plane. In order to correctly orientate this cut and the implant, Whitesides line (deepest part of the trochlear groove), the posterior condylar axis or the transepicondylar axis (TEA) are used. In joints with pre-existing trochlear dysplasia or post-traumatic deformity, Whiteside’s line may be difficult to define and the cut for the anterior flange of the prosthesis is made parallel to the TEA. Removal of more bone laterally results in the cut surface resembling a grand piano [26]. This visual cue on the left knee is recognised by many Australian trained orthopaedic surgeons as resembling a map of Northern Australia.

**Coronal Positioning**

The femoral component is placed in the coronal plane in a position to capture the patella in the initial arc of flexion so as to act like a funnel. In order to achieve the correct coronal positioning, proprietary instrumentation which is specific to the implant design is required. Trials help determine the correct size and a cutting guide is then positioned and secured so that it is in anatomical rotation (**figure 2**).

If an anatomical cut is used, the patella may require ‘centering’ and this can be achieved either through medialising the patella, performing a lateral release or a tibial tubercle osteotomy[27]. In a functionally placed anterior cut, increased external rotation may reduce the need for such alterations to the extensor mechanism.

Whilst alignment in the coronal plane (varus/valgus) should be anatomical, it is largely determined by the bony anatomy of the femur. The dual goals related to the coronal alignment are to capture the patella proximally in early flexion and obtain a smooth transition of the distal end of the implant with the femoral condyles on both sides of the femur distally. Subsequent milling ensures that the femoral
component is placed at the correct depth. In this step the component is placed in line with the anatomical axis of the femur such that proximally the trochlear groove will line up with the shaft of the patient’s femur (figure 2). The distal contour of the trochlear component must also match the contours of the femoral condyle articular cartilage to ensure there is no catching or step as the patella moves from articulating with the trochlear component to the intercondylar region of the femur. Any mismatch at the metal-cartilage junction on either side of the knee but especially laterally risks creating mechanical catching. This phenomenon has previously been described by Hernigou et al in great detail[28]. To ensure this perfect match, the trochlear component may need to be rotated to a valgus position with the long axis of the component directed more obliquely downwards and medially. Errors in positioning in the coronal plane may also lead to issues with patella tracking early in flexion. A component placed in varus may result in the sensation of the patella jumping into the trochlear groove during the early part of flexion due to the trochlear groove being placed in a medial position producing the familiar J tracking. Conversely, where there is excessive femoral valgus such as that seen in patients with a dysmorphic femur, the axis of the femoral shaft should be utilised as the guide for coronal positioning rather than the distal femoral joint line which may lead to a compromise with the distal junction. In this setting, it is the junction of the implant and native femur laterally which takes priority over the medial side.

Sizing

Finally, the femoral component should be sized and positioned such that there is no overhang of the prosthesis medially or laterally and the implant will not overhang into the intercondylar notch. Most propriety systems are designed so that differences in size result in a width difference of 4-6mm and the length of the anterior flange changes. In order to avoid over-hang medially-laterally, it may necessary to have a slight under sizing of the femoral component. It is particularly important that the lateral edge of the femoral component matches the anterior cut. When trialling the prosthesis and placing the definitive implant, it is of paramount importance that the implant is flush with the native femoral cartilage that is remaining to avoid impingement or the feeling of catching. In cases of severe dysplasia, the femoral component may be difficult to make flush with the cartilage and in such cases the component should be slightly recessed in order to avoid any protrusion which will result in catching as the patella passes over the edge with flexion and extension. In some cases, flexion of the femoral component may be required to achieve a flush surface distally with the native trochlear groove. This needs to be done carefully so as to avoid catching of the patella when it engages the femoral component in early flexion particularly in patients with patella alta.

The Patella

- Aim for a residual patella thickness of more than 14mm after preparation, and never less than 12mm
- In patients with patella alta, the patellar implant should positioned on the lower part of the cut surface
- Final implant tracking should be smooth with no catching, snapping, or tilting

The goals of patella resurfacing are to create a combined construct of the remaining native patella and polyethylene that is equal to the thickness of the original patella, is well covered by polyethylene, is flat (free of tilt) and tracks stably within the prosthetic trochlea groove (figure 6).

The two common methods for patella preparation are to use an oscillating saw with or without a cutting jig or to use a mill. The disadvantages of a saw relate to difficulty observing the anterior patella cortex at the time of cutting, such that it is possible to remove either too much or too little bone or to
cut the patella in an incorrect plane removing excessive bone, commonly medially but also distally altering patellofemoral kinematics. To prevent patella maltracking, the component should be medialised and the lateral osteophytes should be removed to avoid bony impingement[26]. We try, where feasible, to match the centre of the patellar implant with the original median ridge but this landmark is usually worn and unidentifiable in cases of severe patellofemoral arthritis.

**In-lay Technique**

Soft tissue around the patellar is first cleared and patella thickness is measured using a calliper. Proximal to distal patella symmetry is evaluated and flattened where necessary with an oscillating saw which is also utilised to perform a small oblique lateral patella facetectomy. These actions help ensure a flat proximal to distal cut and deepens the position of the teeth on the lateral side of the inlay capture ensuring the final patellar surface is close to parallel to the anterior surface or slightly thicker medially and equally thick proximal to distal.

The largest patellar capture ring that is stable to rotation when positioned on the patella is utilised and is secured to the patella via a clamp. During this step the teeth of the capturing ring should be seated on the patellar surface. The position of the teeth medially and laterally corresponds to the resection depth of the mill. The ring has a concave shape medial to lateral and is slightly asymmetrical to match the cross-sectional shape of the patella with the apex of the concavity being approximately one third of the way across the patella from the medial side [29] (figure 4). When performing a lateral arthrotomy for exposure, this particular point should be borne in mind as the patella will be everted medially. The position of the capture ring is determined by its stability against the patella and is usually not the actual ideal position for the implant and often need adjustment.

Milling systems contains depth stop to control the amount of remaining bone as well as a separate stop to guide the amount of bone to be removed (figure 5). The residual bone thickness will vary depending on the pre-disease thickness size of the patella with the goal of restoring the combined patellar and implant thickness close to the pre-disease size of the patient which is generally between 22-28mm.

Any remaining rim of bone is removed either with an oscillating saw or rongeur and trial implants are positioned to choose the largest trial implant that does not create overhanging. It is positioned flush with the medial edge or aligned with the original median ridge if that landmark remains. Medialising the implant on the patellar cut surface may improve patella tracking in some cases as previously described by Insall[30] and Whiteside et al.[31]. Holes for the pegs on the patellar component are drilled. After the application of the trial component, the total thickness is remeasured and tracking assessed. During tracking the medial edge of the patella is observed and expected to articulate with the medial trochlea at 30 degrees of flexion prior to the insertion of any sutures. A lateral release is rarely required and should be avoided as it has been shown to increases the risk of patella fracture 2.7 times [32]. Whilst a residual remnant bone thickness for the patella after preparation is recommended to be at least 12 mm, we try to keep the minimum remaining thickness to 14 mm. Results are inconclusive with some studies showing a higher rate of fracture with residual thickness of less than 12mm [32], and others no difference [33]. Remaining thickness should to be titrated to take into consideration the patients gender, BMI and the presence of osteoporosis. A BMI greater than 30 kg/m2 has been shown to have a 6.3-fold and 1.7-fold increase in risk of loosening and fracture respectively[32]. Also, a pre-operative thickness of <18mm has been shown to be a risk factor for periprosthetic patella fracture[33] as has osteoporosis [34]. In cases of a severely thin or worn patella, Ogdaard et al describe [35] a conservative cut to the severely worn facet, such that 10 mm is preserved, and a thicker cement layer is accepted with the cut being performed parallel to the anterior surface of the patella.

If during assessment of patellar the implant catches proximally on the upper edge of the trochlear, this indicate uncorrected patella alta [17]. In such cases the patellar implant can be positioned on the lower part of the cut surface ensuring smooth motion of the patella with no catching, snapping or tilting. This has been associated with good final functional and mechanical outcomes in PFA [36]. We have not ever had to distalise the tibial tubercle but this remains an option in the case of severe patellar alta.
Following surgery, we mobilise the patients on the same day and aim for discharge from hospital directly home when the patients function allows. The rehabilitation regime is similar to that following TKA, with emphasis on strengthen and conditioning of the quadriceps muscle as these are often deficient in patient patients PFOA.

**Future Directions**

Since the first published series on the outcome of isolated PFA, there has been significant advancements in implant design resulting in improvement in clinical outcomes. Despite these improvements, revision rates at 10 years on some registries remain as high as 20%[37] which is markedly higher than the often quoted figure of 0.5% per annum for TKA. Whilst patient selection remains key to achieving good outcomes and lower revision rates, precise implant positioning is also required. With the development of robotically-assisted tools for arthroplasty, virtual planning for 3D placement of components has become possible with a high degree of precision and accuracy. Such technology enables the surgeon to place the implant with 6 degrees of freedom to ensure congruency between the patient’s native anatomy and the prosthesis[38]. This technology is in its infancy, and is also not yet widely available. Whilst the proposed benefits are promising, time and published data will clarify their true worth to PFA.

Continued collection of operative data and its comparison with outcome scores using artificial intelligence may guide surgeons to personalize implant position and improved bone cuts based on patient characteristics. Navigation and robotically assisted patellar bone cuts and implant positioning is in its infancy and future development is likely.

**Conclusion**

The key to a successful PFA requires the combination of appropriate patient selection, use of newer generation prostheses and precise implant positioning. A successful surgical technique requires the surgeon to place appropriately sized components in relation to well described anatomical landmarks in such a fashion as to ensure a smooth motion of the patella through an arc of flexion, free of any incongruity. Clinical outcomes are unforgiving when there is a deviation from any of the aforementioned specifications. New technologies may aid surgeons in their ability to precisely place implants, however outcome data is yet to come.

**References:**


Figures:

Figure 1. Patellofemoral Implant Design
Patellofemoral arthroplasty prosthesis have undergone several generations of evolution. Design A represents the Gender Solutions patellofemoral prosthesis (Zimmer Biomet) and design B represents the Avon (Stryker) patellofemoral prosthesis.

Figure 2. Alignment of the trochlea with the anatomical axis of the femur.
The trochlea groove of the trochlea should align with the anatomical axis of the femur.

Figure 3. Femoral instrumentation
An anterior cutting guide with a gauge is attached to a stabilising intra-medullary rod to determine the anterior cut (A). The gauge determines the thickness of the femoral resection and avoids notching the anterior cortex (B).

Figure 4. Capture ring positioning for patella milling
The capturing ring should be seated on the patellar surface. The ring has a concave shape medial to lateral and is slightly asymmetrical to match the cross-sectional shape of the patella (A). The position of the teeth corresponds to the resection depth of the mill (B).

**Figure 5. Resection depth and milling**

Milling systems contain a depth stop that controls the amount of remaining bone (A) as well as a separate stop to guide the amount of bone to be removed (B).

**Figure 6. Final component positioning**

The final components should be placed such that trochlea is slightly lateralised (A) and faces the patella (slight external rotation) B. The patella is brought towards the trochlea by being placed in a slightly medial position.

**Pearls and Pitfalls**

- Appropriate patient selection is critical to a successful outcome – always obtain consent from the patient to proceed to a total knee arthroplasty in anticipation of finding that the joint is not suitable for receiving an isolated PFA after performing the arthrotomy.
- Avoid a lateral release at all costs if a medial arthrotomy has been performed due to the risk of vascular necrosis and patella fracture.
- The critical goal of femoral component placement is to ensure a smooth transition of the patella through an arc of flexion – avoid incongruity between the cartilage and implant.
- If a lateral release is considered likely due to excessive tightness and pre operative lateral tilt, a lateral arthrotomy should be considered.
- Aim for a residual patella thickness of 14mm after preparation, and never less than 12mm.
- In patients with patella alta, the patellar implant should positioned on the lower part of the cut surface.
- Final implant tracking should be smooth with no catching, snapping, or tilting.
Anatomical axis

Mechanical axis

Valgus coronal of femoral component aligns with the anatomical axis of the femur
Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: