Unicompartmental arthritis in the aging athlete: osteotomy and beyond

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Abstract The vitality of the aging athlete is largely dependent on continued mobility and pain-free motion. The early onset of osteoarthritis often has devastating consequences for these athletes and if left untreated, mobility declines and eventually prevents sporting activities all together. Recent advances in operative treatment for unicompartmental arthritis of the knee aim to delay the need for total joint arthroplasty by preserving or restoring the form and function of the knee to allow for continued sport participation. This review focuses on the recent literature of several surgical treatment options for unicompartmental disease including cartilage procedures, osteotomy, and unicompartmental arthroplasty.

Keywords Unicompartmental arthritis · Microfracture · Unicompartmental arthroplasty · High tibial osteotomy · Autologous chondrocyte implantation · Mosaicplasty · OATS

Introduction

Osteoarthritis of the knee is a common and painful process. It may begin as an isolated articular lesion or may be localized to a single compartment. Unfortunately, pain and debilitation occur often well before a patient may be clinically appropriate for a total knee arthroplasty (TKA), particularly because they are often young and active [1, 2]. While a TKA may be the ultimate end for many patients,

it still remains an imperfect construct that has the potential for significant morbidity [3].

Alternatives to TKA aim to minimize complications and return patients to an active, pain-free lifestyle. Historically, operative techniques to manage isolated unicompartment arthritis include osteotomy and limited arthroplasty techniques. Regarding osteotomy, high tibial osteotomy (HTO) is performed in the setting of varus malalignment and medial arthritis. Good results are reported in conjunction with closing wedge and opening wedge osteotomies, though complications such as non-unions and fracture are fairly common [4, 5]. Other osteotomies to consider in isolated lateral or patellofemoral arthritis include distal femoral or tibial tubercle osteotomy, respectively.

The unicompartmental knee arthroplasty (UKA) is advocated in place of the TKA in active patients that wish to maintain a high-level of functioning while decreasing operative morbidity [6]. While patient-reported outcomes are good, the younger, more active patient population receiving the UKA predisposes the implants to wear and the potential need for revision and conversion to TKA [7, 8•]. While the majority of unicompartment arthroplasty is performed for the medial compartment, techniques have evolved to include lateral UKA and isolated patellofemoral arthroplasty as well.

Cartilage procedures for isolated compartment disease include marrow stimulating techniques, osteochondral transplantation (autograft and allograft), and cell-based techniques. Typically, these procedures are indicated for focal chondral lesions and are contraindicated in the setting of diffuse osteoarthritis. However, in certain cases of early unicompartment osteoarthritis, consideration may be given to these techniques, particularly in combination with a realignment procedure.

Due to the various options available for the management of unicompartmental knee OA, it is of the utmost importance for the orthopaedic surgeon to gain familiarity with each of these

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procedures, understand the patient indications, and recognize the advantages and disadvantages of each treatment option.

Cartilage restoration

Significant energy is currently being applied to restore or regenerate a native cartilage surface in the knee. Microfracture, osteochondral transplantation (OATs), and Autologous Chondrocyte Implantation (ACI) are 3 current treatments for isolated cartilage lesions. The microfracture technique penetrates subchondral bone with an awl and relies on chondrocyte stem cells from marrow to settle into the osteochondral defect. The OATs procedure takes whole osteochondral plugs from nearby non-weightbearing areas of the knee. This technique requires recreating the curve of the articular surface and bone healing at the base of the osteochondral plug. In contrast, ACI in its current 2 stage method harvests chondrocytes during stage I, expands them in the lab either in solution or on a scaffold, and subsequently reimplants them in the chondral defect during the second stage. As enticing as these methods may seem, are they appropriate for the aging patient?

Age (numerical or functional) is a critical factor that reduces the benefits of cartilage regeneration treatments. Older patients are more likely to have osteoarthritic lesions and in general the state of their cartilage is poorer than younger patients. While older patients do see improvement, the best results have been with younger patients (< 40 years old) with OCD or traumatic lesions that are less than 12 months old [9]. Moreover, small lesions (< 4 cm²) did better than larger lesions, though OATS and ACI were more adaptable to lesions larger than this [10, 11•]. Richard Steadman, the developer of the microfracture technique, published 11-year data that demonstrated a dampening effect as the age of the patient increased [12]. Kreuz and colleagues found similar results in terms of subjective evaluation and MRI analysis of defect filling when they used 40 years as the age division [13].

ACI also failed to overcome the age factor. Kon specifically looked at patients over 40 and while they improved, their response was less than reported younger cohorts and their early failure rate was higher [14, 15]. Consensus is hard to achieve in medicine and Niemeyer's 2010 ACI data states that age >40 does not preclude one from receiving benefit [16]. Results were slightly higher with his first generation (porcine membrane ACI) and equal to his younger cohort. They emphasize that "relevant degenerative changes in terms of arthritis" did not exist. While numerical age is only a number, cartilage restoration techniques should only be applied to those who have limited, non-arthritic relatively new-onset lesions. Otherwise, discussions should center first on non-operative treatments and then on High-

tibial osteotomies, unicondylar knee arthroplasty, and total knee arthroplasty.

High tibial osteotomies (HTO)

When a chondral lesion is large, bipolar (ie, Involvement of both femur and tibia), or the patient's age becomes prohibitive (>45), consideration should be given to high tibial osteotomies (HTO) and unicondylar knee arthroplasty (UKA). Despite the existence of both for several decades, debate still exists in the literature. Most papers agree that in general, HTO is a more reasonable option for younger more active patients (<65) with a varus knee and medial compartment OA; while increased age and lower activity levels are better candidates for UKA [17, 18]. There is considerable overlap, however, and it is unlikely that a definitive answer will occur.

Many techniques exist for HTO to treat medial compartment disease: lateral closing wedge osteotomy, medial opening wedge, and domed technique. Different cut placements and tibial slope alterations have also been described [19]. The main goal of all of these is to restore the mechanical alignment, retain stability of the knee, and reduce collateral malalignments such as patellofemoral maltracking. Several recent papers have discussed some of these alignment issues [20–22].

The real question of HTO, however, is survival and performance. A 1999 paper by Naudie set the bar [23]. In a 10- to 22-year follow-up, overall 5-, 10-, 15-, and 20-year survival rates were 73 %, 51 %, 39 %, and 30 %, respectively. Given this information, it is conventional thinking that HTO is beneficial for younger patients. In a subset population of those <60 years old with good pre-operative knee flexion, survival rates at 5, 10, and 15 years were 95 %, 80 %, and 60 %, respectively [23]. Current research has supported these trends. In a study of 413 patients, probability of survival was 95 % at 5 years, 79 % at 10 years, and 56 % at 15 years [24]. A recent meta-analysis by Spahn does not differ significantly from these numbers [25•]. The Finnish registry survival data published this year reproduced these numbers. The authors reported 89 % survival at 5 years and 73 % at 10 years [26]. All 3 of these studies have shown that younger patients have lower rates of conversion to TKA. While lower failure rates were evident, functional outcome was not different between age groups.

With HTO promoted for younger patients, it would stand to reason that it performs well with return to sport. Two retrospective reviews in the last 3 years reported positive return to sporting activities [27, 28]. Salzmänn published the results of 65 patients of whom 90.9 % were again engaged in sports and recreational activities including skiing and mountain biking. There were few changes in the hours

devoted to activity before or after HTO. The Lysholm and Visual Analog Pain scales also improved (42.4=>69.9 and 6.9=>2.9 respectively.) Bonnin asked this question to 139 patients of whom 20.9 % were more active than before, 44.6 % that were as active as pre-operatively and 33 % who were less active. In part, the study evaluated motivation of the patient and found a correlation between motivation and activity level [28].

Unicondylar knee arthroplasty (UKA)

The other current option for extensive degenerative lesions within a single compartment is the Unicondylar Knee Arthroplasty (UKA.) While the HTO is thought of more as a younger patient option, the UKA is well-suited to older patients. Other indications defined over the years are an intact ACL, flexion deformity <15°, and <15° varus deformity [29]. In part, the concerns over wear properties of Unicondylar Knee Arthroplasty have preserved its indications for an older, less active patient. However, at least one recent research paper has challenged this notion and extended the indication to below 60 years of age [7]. Felts reported a 95 % 12-year survival in 65 patients (mean age 54.7 years) with 7 being revised. Seventy-eight percent reported running with moderate to no discomfort though pivoting seemed to be a concern. Forty percent reported extreme discomfort suggesting more success with inline activities. Foran also published highly successful survival rates for medial UKA's with 93 % 15-year survival rates and 90 % 20- year survival rates [29]. Large scale data comparing the Australian and Swedish knee registries for UKA on patients under 65 did not confirm the exceptional survival data [30]. At 7 years, the survival rate in Australia and Sweden were 84 % and 88 %, respectively. Over 50 % were revised for aseptic loosening and most converted to TKA's. They emphasized that for younger more active patients, the high likelihood of future revision must be discussed.

Because loosening and wear are significant issues with any prosthesis, the amount of force driven across it is of concern. Activity is 1 means of increasing wear, but so is increased body mass (BMI). A 2011 paper by Bonutti stratified patients receiving UKA with BMI>35 and <35 [31]. At a mean of 33 months, 5 of 34 knees above BMI 35 had revisions while 0 revisions occurred in 33 knees with less than 35 BMI. This is not a new finding but highlights the difficulty with employing UKA without consideration for the patient as a whole.

Fixed vs mobile bearing on the medial side has been a long debate within UKA literature. Parette et al attempted to settle this issue with a study evaluating basics such as survival and knee function [32]. Knee Society function scores were equivalent in both groups. Survival data also showed no differences

with 83 % at 20 years for fixed bearing and 80 % for mobile bearing. The endpoint was defined as revision for any reason. Wear was indeed more of an issue with fixed bearing as 4/79 required polyethylene exchanges at an average of 8.9 years. The mobile bearing group had a zero failure rate due to poly wear. Conversely, mobile bearing, with its unattached polyethylene, had 3/77 revised to total knees. From a radiographic standpoint, Parette and colleagues observed more overcorrection in the mobile bearing group, which was hypothesized to be due to the concern over bearing dislocation and therefore “over-stuffing” of the compartment [32].

UKA vs HTO

The loss of bone stock and risks of prosthesis failure in UKA, vs slower recovery times and difficulty in establishing correct valgus alignment in HTO leads to considerable debate of which is better, HTO or UKA. Moreover, as Dettoni states in his comparative review, there is considerable overlap in indications for a certain set of patients: 55–65 years old, moderately active, non-obese, mild varus malalignment, no joint instability, good range of motion, and moderate unicompartmental arthritis [17]. With conversion to TKA as the standard revision, the ease of this conversion has to be incorporated into the decision. Head-to-head comparisons between HTO and UKA have been discussed in recent literature.

Survival is not the only outcome measure when examining these procedures. Recovery and mid-term performance also need to be assessed. Yim compared HTO and UKA together with a minimum follow-up of 3 years [33]. In this study, the patient profiles bracketed the overlap between HTO and UKA with the average age being 58 in the HTO group and 60 in the UKA group. The focus was return to activity levels and functional knee scores. Return to activity was reduced in both groups but not significantly different between them. Thirty-nine of 50 in the HTO group who previously participated in recreational activities returned to them. In the UKA group, 30/42 pre-operative active patients returned to activity. Lysholm scores and Tegner activity scores did not differ. The only difference found was the post-operative alignment. Equal before surgery, the UKA remained in an average of 1.9° varus—likely from fear of overstuffing the joint—and 1.8° valgus for the osteotomy group. In terms of recovery, weight bearing was begun almost immediately with UKA; while it was 6 weeks before partial weight bearing was allowed for HTO.

Takeuchi looked at a Japanese population for which a high degree of flexion is necessary for cultural sitting postures [34]. It is the ideal population to test functionality of the knee in terms of range of motion and would reveal significant differences between HTO and UKA if they existed. They used an opening wedge osteotomy and Nakashima UKA implant. No

significant differences were found in the revision rates, complications, or Knee Society Score (KSS). It was the Knee Society Functional Score that did reveal a significant difference favouring the HTO. Despite this, there was no difference in the improvement ratio of flexion angle. The HTO group had a greater degree of flexion at the onset. Their conclusion suggests that HTO's are better for patients requiring a higher degree of function and good range of motion.

Spahn et al attempted to resolve the debate with decades of data for HTO and UKA in 2011 with a meta-analysis [25]. A total of 89 studies were deemed robust enough for inclusion (46 reporting on the HTO and 43 on the UKA). As mentioned above, the mantra has been: HTO's for younger more active patients and UKA's for older less active patients. The cumulative data demonstrated that the average age of the HTO is 56.1 years and 70.1 years for UKA. Survival data was comparative with HTO failing more frequently after 12 years. For HTO, survival was 91 % at 5 years, 84 % between 9–12 years and 70.1 % 12 years and above. UKA survival data was 91.5 % at 5 years, 86.9 % between 9–12 years and 77.5 % 12 years and above. Complication rates favored UKA as well with a 13.8 % complication rate for HTO and 11.3 % for UKA. Spahn sums with the statement, "The most important finding of this study was both valgus HTO and medial UKA are sufficient operative treatment options for symptomatic medial knee osteoarthritis." He and his colleagues also restated the belief that HTO's were more suited to younger more active patients and the UKA for older patients with decreased activity levels.

The final comparative question is which can be more easily converted to a TKA? While previous reports have suggested a prior HTO makes a TKA more technically demanding and of poorer quality, Meding in his analysis suggested the knee performance scores and survivorship were not different [35]. Thirty-nine knees with TKA after HTO and each with a contralateral total knee were followed for an average of 14 years and evaluated with the Knee Society Score. No differences were reported in the KSS and survivorship at 15 years was 100 % for the primary TKA and 97 % for the TKA with prior HTO.

Pearse et al using the New Zealand registry looked at primary TKA vs UKA in patients who had unicompartmental arthritis but were clinically eligible for a TKA [18]. Data indicated that while a UKA does not have a poorer revision or functional outcome than HTO in its primary state, when converted to TKA, the UKA performs poorly. Functionally, 41 % of the patients in their data pool had a poor Oxford Knee Score with revision to TKA. Additional data suggested that the complexity of revision favored HTO. Only 2.4 % of HTO to TKA revisions required some form of stemmed component, whereas 28.3 % of UKA to TKA patients required revision components. This is critical if failure occurs again.

Lateral compartment arthritis

The valgus knee with OA is less common compared with the varus knee with OA. The screw home mechanism also presents different challenges for prosthetic design. The literature is impoverished for isolated lateral compartment arthritis treatments—HTO or UKA. In part, the lack of data may stem from Coventry's recommendation to perform distal femoral osteotomies for malalignments of 20° or more, making HTO much less common. As for UKA's, in 21 years Ashraf and partners performed only 88 lateral UKA's [36]. Similarly, over 13 years Pennington performed 357 UKAs of which only 29 were lateral UKA's [37]. Despite the lack of data, the same decision exists between realignment and arthroplasty.

To shift the mechanical alignment medially, either medial closing wedge or lateral opening wedge would suffice. Coventry described the medial closing wedge in 1987 with a case series of 31 knees [38]. Six (19 %) knees progressed to a total knee at 9.8 years on average with 24 (77 %) having either no pain or occasional mild pain. No wound or union issues were encountered.

More recently the lateral opening wedge osteotomy has been reported. Only 2 series were identified, the first published in 2001 by Marti of 36 knees over a 21 year span, and the second by Collins in 2012 [39, 40]. The studies differed in 2 major ways. While Marti's cohort consisted overwhelmingly of post-traumatic valgus deformities, Collins' population was mainly arthritic wear. The second was a technical difference. Marti's opening osteotomy included a fibular osteotomy while Collins' preserved the fibula. Compared with medial closing wedges, advantages of the opening osteotomy are avoidance of causing lax medial ligamentous structures. Disadvantages are potential nerve palsies, non-unions, and patella baja. Marti's patients had results according to Lysholm scores of 26 % excellent, 62 % good, 9 % fair, and poor in 1 patient or 3 %. The average preoperative tibiofemoral angle was 11.6°, which was corrected on average to between 4–6°. The exception was in 4 patients with an etiology of previous osteotomy. Their initial angles averaged 18.3 and were only corrected to 12.3°. Some debate exists as to the ideal correction. Recommendations exist to correct the angle to less than 7° without completely correcting the deformity so as not to overload the medial compartment nor destabilize the ligamentous balance of the knee. Others surmise that 0° remains the ideal end resultant angle [37–39]. Transient complications included 3 peroneal nerve palsies, which resolved 1 superficial wound infection, and 5 knees with moderate instability. With failure being progression to arthroplasty or another corrective surgery, only 1 occurred. In the poor result, an arthrodesis was performed for intractable pain. Of note, Marti stated age did not play a role in his indication criteria.

Collins' 2011 paper reports on 23 patients with an average mechanical axis of 2.4° valgus knee and 6.9 anatomic axis.

Rather than predominantly post-traumatic valgus knee patients, their composition was mainly osteoarthritis, previous lateral meniscectomy, and osteochondral lesions. The one consistency in the operative technique was preservation of the fibula without osteotomy; otherwise, different fixations were used and some were bonegrafted while others were not. The KOOS score and lower extremity function scale both improved. The mechanical axis change was only 2.4° and anatomic axis 2.3° although reported as statistically significant. An innovation from other studies was their use of gait analysis and the peak adduction moment as a surrogate for medial compartment loading. Twelve patients underwent analysis pre and postoperatively. A statistically significant improvement occurred from 1.27 % BW*Ht to 1.90 % BW*Ht. Only 2 (10 %) patients in the overall cohort proceeded to total knee after 2 years though 38 % required a second procedure [40]. While innovative and commendable for gait analysis, this paper would seem to have significant limitations and questionable efficacy. The length of follow-up is adequate to prove safety but not overall efficacy. With 10 % already progressing inside 2 years to a total knee, longer term results are needed before full assessment can be passed. While the change in adduction moment arm was statistically significant, the question remains whether the shift in weight is actually clinically significant. Moreover, most of the knees operated on were within an acceptable valgus angle preoperatively. For small corrections and etiologies of osteoarthritis rather than post-traumatic malalignments, the lateral UKA becomes an attractive option.

As HTO for valgus knees are infrequent, so too are lateral UKA's. Oft repeated data states they comprise only 10 % of all UKA's and approximately 1 % of all knee arthroplasties [41, 42]. The relative dearth is likely both a true lower incidence, but also a bias towards the more familiar TKA. Indications are similar to medial UKA's: isolated lateral compartment arthritis (though asymptomatic patellofemoral arthritis is not a contraindication), preservation of medial cartilage, intact ACL, and correctable valgus deformity.

Long-term follow-up has been published by Ashraf in 2002 [36]. He reports on his experience over 21 years (1978–1999) with 88 lateral UKAs. A single prosthesis was used, the St. George Sled, which is a cemented all polyethylene tibial component and metal femoral component. Survivorship analyses places this prosthesis at 83 % at 10 years and 74 % at 15 years making it comparable with the Swedish registry data but not individual studies such as Foran's 90 % 20 year survival rate for medial UKAs [29]. While there were no aseptic loosening, 15 knees (17 %) were revised at an average of 8 years to a total knee, most commonly for progression of arthritis. In certain terms this is less than useful data (as are most long term survival rates) for only 1 type of prosthesis was used, which highlights its particular longevity, but cannot necessarily be extended to other prostheses. Furthermore,

survival does not necessarily indicate quality nor current state of the prosthesis. No consistent criteria for revision in these studies exist.

Twelve years of data were analysed by Pennington et al [37] in which 29 lateral UKAs using the Miller Galante System were performed in these years. Upon publication in 2006, no revisions had occurred and all knees were good to excellent with average post-operative HSS scores of 93. Pennington ascribes these excellent results in part to their unique placement of the tibial component. The "screw home" mechanism of the knee joint causes the lateral condyle of the femur to internally rotate 4° during the last 60° of leg extension corresponding to forward rolling of the femoral condyle on the tibia. Given this, the authors observed the femoral component riding onto the tibial spine. Their tibial tray placement was purposefully internally rotated $10\text{--}15^\circ$ to accommodate the translation of the femur. It remains to be seen if this truly had any effect on their results. It is an interesting adjustment that may redirect prosthesis innovation.

The lateral UKA is reported to be more difficult technically given the more active biomechanics of femoral roll-back and the screw home mechanism [37]. Dislocation of the polyethylene is a known complication of mobile bearing prostheses. It has been recorded as high as 10 % in the early Oxford knee designs [43]. Robinson et al looked at the Oxford knee dislocations to establish a technical cause [44]. The most recent alteration to the Oxford knee mobile bearing system was a domed tibial component and a biconcave polyethylene bearing, hypothesized to increase contact and reduce dislocation. Results by Streit et al showed a dislocation rate of 6.2 % in 50 subjects giving a relative dislocation reduction of 38 % with absolute reduction of 3.8 % (10 % down to 6.2 % dislocation.) The elevation of the joint line or creating a varus angle resulted in a greater likelihood for dislocation.

As intimated in this review not all arthritis is the same. Sah assessed his series of lateral compartment arthritic knees treated with lateral UKAs and attempted to distinguish between degenerative arthritis and post-traumatic arthritis [42]. Of 49 lateral UKA's in 13 years, 10 were post-traumatic arthritic knees. Johnson & Johnson prostheses were used during the data collection period (Brigham unicondylar and Press Fit Condylar). In all patients, there were no revisions after an average of 5 years follow-up. One patient at 16 years had osteolysis and a conversion to a TKA was recommended. The post-traumatic group, however, required thicker polyethylene inserts and recorded poorer knee scores. Post-operative Knee Society knee and function scores were 74 and 65, respectively, compared with 95 and 86 in the primary osteoarthritic group. While more evidence is needed, it hints that post-traumatic knees may be better suited to an initial TKA.

Overall, these studies continue to support the lateral UKA as a confident option. Though improved, a question mark still remains for the benefits of mobile bearing inserts for lateral UKAs compared with its dislocation risk, something not seen as overtly with medial UKAs or TKAs. Otherwise, the literature is fragmented, each with a different angle and no head-to-head comparisons.

Patellofemoral arthritis

As with medial and lateral compartment arthritis various treatment options exist for isolated patellofemoral disease. Cartilage procedures, osteotomies, and arthroplasty techniques have all been described in the literature and their applications vary depending on the type of disease present, patient characteristics, and surgeon preference.

Cartilage restoration

Cartilage restoration techniques with or without patellar realignment procedures including microfracture, ACI, DeNovo, osteochondral allograft transplant, and osteochondral autograft transplant have been described but results are generally reported in young patients. As with cartilage restoration techniques in the lateral and medial compartments of the knee, cartilage procedures of the patellofemoral joint should be reserved for isolated chondral defects without evidence of diffuse osteoarthritis. In a recent systematic review of studies in which patients averaged 33 years of age, Trinh and colleagues reported that ACI with or without realignment osteotomy demonstrated improved clinical outcomes. Also of note was a significantly greater improvement in patients that received both ACI and previous or concomitant realignment osteotomy when compared with ACI alone [45]. While many other studies exist, further discussion of patellofemoral cartilage techniques is beyond the scope of this article.

Osteotomy

Several displacement osteotomies of the tibial tubercle have been described for the treatment of anterior knee pain and isolated OA of the patellofemoral joint. Historical techniques include the original medial-displacing Elmslie-Trillat procedure, the tibial tubercle elevating Maquet osteotomy, and the anteromedialization Fulkerson osteotomy. While good results were reported with the Maquet osteotomy, long-term follow-up studies demonstrated high complication rates, which included non-unions, fractures, and wound healing issues [46, 47]. Improved clinical outcomes with lower complication rates were reported with the Fulkerson osteotomy though non-unions and proximal tibia fracture still occurred [48–50]. In a recent retrospective review of 50 consecutive tibial tubercle

advancement osteotomies with femoral head allograft, 40 % with tibial tubercle medialization, and 10 % with lateral femoral trochleaplasties, Atkinson et al reported these techniques achieved good-excellent results in treating anterior knee pain and patellofemoral chondral damage in the majority of patients. The major complication rate was 12 % and included 1 transient neuropraxia of the peroneal nerve, 2 intraoperative tibial metaphyseal fractures, and 3 postoperative tibial tuberosity fractures. Superficial wound infections were experienced in 8 % of cases. It should be noted that as with reports of cartilage procedures, the mean age of patients in this study was 29 with a maximum age of 51 [51].

Patellofemoral arthroplasty

Patellofemoral arthroplasty (PFA) techniques are also a viable option for patients with isolated patellofemoral disease. Patellofemoral arthroplasty techniques are generally reserved for patients that have failed extensive periods of conservative management for intractable anterior knee pain, are somewhat younger (50s), and do not have malalignment issues [52]. In a recent long term follow-up study of 161 patients receiving PFA, van Jonbergen and colleagues reported 84 % and 69 % survivorship at 10 and 20 years, respectively. Patients averaged 52 years of age and included those with primary patellofemoral osteoarthritis, post-traumatic osteoarthritis, or patellofemoral arthritis with previous realignment procedure. While obese patients were more likely to require revision, the authors could not find an association of revision with primary diagnosis, sex nor age [53]. A similar study of 43 PFA procedures at mean 7-year follow-up reported successful clinical and radiographic outcomes with 88 % survivorship at final follow-up. Mean Knee Society objective scores improved from 64 preoperatively to 87 post-operatively and functional scores improved from 48 preoperatively to 82 post-operatively [54].

In a study of 4643 PFA in the National Joint Registry of England and Wales, Baker et al reported 195 revisions at a median of 2 years after index procedure. Continued pain was cited as the most common reason for revision in 72/158 (46 %) cases while progression of OA was the main reason for revision in 22/158 (14 %) cases. When compared with a matched group of total knee arthroplasties, continued pain was almost twice as likely in the PFA group as the reasoning for revision. The authors suggested that this may be due in part to inadequate patient selection [55].

Few studies have compared the outcomes of PFA with TKA for treatment of isolated patellofemoral arthritis. In 2010 Dahm et al compared 23 PFA with 22 TKA at a mean 29 month follow-up and found similar results among the 2 groups in terms of pain relief. At follow-up, 22 % of PFA patients reported experiencing moderate pain compared with 14 % of TKA patients. The authors reported improved function and

return to activity in the PFA group as well as decreased blood loss and fewer complications when compared with the TKA group [56]. In contrast, a recent meta-analysis of 28 studies examining complications in PFA vs TKA reported that patients receiving PFA were more likely to experience complications and the need for revision. Patients averaged 56.6 years in the PFA group and 59.6 years in the TKA group with a mean follow-up time of approximately 6.5 years in both groups. When examining both 1st and 2nd generation PFA implants as 1 group vs TKA, PFA patients were over 5 times more likely to experience complications and 8 times more likely to require revision. First generation PFA implants were almost 3 times more likely to experience complications and almost 5 times more likely to require revision when compared with the second generation PFA implants. Second generation PFA implants were not significantly different from TKA in terms of revision, pain, or mechanical symptoms [57]. These results indicate that PFA may become an even more viable option for selected patients with isolated patellofemoral arthritis as implant design continues to improve.

Conclusions

Unicompartmental arthritis in the older adult is a difficult problem. It is less amenable to regenerative or restorative treatments such as microfracture, osteochondral autologous transplant, and autologous chondrocyte implantation. More proven treatments are the high tibial osteotomy and the unicompartmental knee arthroplasty. Both are safe and effective but each has its pros and cons. The HTO preserves bone stock, does not compromise conversion to TKA, and can perform effectively even in elite athletes. The long recovery and limited weight bearing in the post-operative period of this controlled fracture, risk of non-union and technical challenges can be a deterrent. In particular, the recovery period for working adults who cannot afford significant time lost may be the real deciding factor. The osteotomy has truly become a lost art as the durability of polyethylene improves and training favors arthroplasty over osteotomy. With better materials and understanding of the arthroplasty—UKA or TKA—they have become less fearful options in a younger patient than in previous times. In addition, quicker recovery, immediate weight bearing, and apparent greater sustainability make the UKA more attractive than HTO. The disadvantages of UKA are greater bone loss, slightly more challenging conversion from UKA to TKA, and possible dislocation of the polyethylene if a mobile bearing prosthesis is used. While each patient must be assessed individually, bias may be at work if the arthroplasties are reserved for a somewhat older and less active population than those receiving HTO's.

In the active patient with unicompartmental knee osteoarthritis we recommend beginning treatment with physical therapy,

NSAIDs, and an unloader brace. Viscosupplementation is performed in patients refractory to conservative management. Patients that fail non-operative treatment are counselled regarding surgical options. Knee arthroscopy with partial meniscectomy should be considered in those patients with mild OA and displaced meniscal tears with primarily mechanical symptoms. In high-demand patients less than 65 years of age with medial compartment OA and varus malalignment we recommend HTO. In lower demand patients greater than 65 years of age with isolated medial or lateral compartment OA, we recommend UKA. Patients with isolated patellofemoral disease are managed conservatively for extended periods of time and operative treatment is only considered when all non-operative means are completely exhausted. In select patients with large patellofemoral chondral defects and intractable anterior knee pain despite conservative management we perform patellofemoral arthroplasty. Finally, total knee arthroplasty should be recommended to the patient with worsening tricompartmental OA.

While guidelines exist, each patient must be assessed individually due to their anatomy, comorbidities, and expectations for recovery and future function. While the hope is to provide the patient with a definitive surgery, each are often waystations to the definitive stop of a total knee.

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