Symposium. Operative Treatment of Patellofemoral Arthritis

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Arthritis of the patellofemoral joint is typically an extremely debilitating condition and is relatively common. Arthritic changes have been found radiographically in the patellofemoral compartment in isolation in 13.6% to 24% of women and in 11% to 15.4% of men in two studies of subjects who were more than fifty-five and sixty years old, respectively. When only patients with symptomatic osteoarthritis of the knee were considered, the prevalence of isolated patellofemoral disease (in patients over fifty-five years old) ranged from 5% to 8%. In a cadaver study of 100 individuals who were more than sixty-five years old at the time of death, 79% had evidence of patellofemoral osteoarthritis, although it was not in isolation.

However, despite the frequency of patellofemoral arthritis, and its various predisposing conditions associated with anterior knee pain, it has historically proven to be relatively refractory to treatment. This is due, in part, to the complexity of the problem, and it reflects a possible previous lack of recognition of the subtleties of the biomechanics at this articulation.

As our understanding of the disease and the biomechanics of the joint has improved, the management of patellofemoral arthritis and its antecedent conditions has also become more clearly defined. Corresponding to the spectrum of disease associated with the degeneration of the patellofemoral joint, a range of management options are currently available and they are continuing to be developed. Although there are areas of controversy, these current treatment modalities, when appropriately applied, are associated with increasingly successful patient outcomes.

There are many current areas of debate with regard to the management of patellofemoral arthritis, but an appreciation of the biomechanics and function of the patellofemoral joint underpins all modern interventions. Some of the current controversies include the precise indications for certain procedures and the types of soft-tissue and osseous realignment procedures.
development in chondrocyte culture and implantation have raised the issue of the use of such treatments in the patellofemoral joint. The question of which patients and which conditions are best suited to these new treatments has also been raised by the recently improved results achieved with unicompartmental patellofemoral arthroplasties. Finally, recent literature has been encouraging with regard to the use of total knee arthroplasty for the treatment of isolated patellofemoral arthritis in certain, particularly older, patients.

The objectives of this symposium, therefore, were to provide an overview of the current understanding of patellofemoral arthritis and of the issues regarding its management and to provide some indication as to how these can be expected to develop in the near future.

**Patellofemoral Joint Function and the Etiology of Patellofemoral Arthritis**

The patellofemoral joint offers challenges because of the unique orchestration of static (ligamentous and osseous) elements and dynamic (neuromuscular) factors that contribute to its functional capacity. Specific elements of the comprehensive examination and investigations critical to determining the nature of patellofemoral joint disorders are gradually covered throughout this symposium. To better understand the possible etiology of patellofemoral arthritis, a brief review of the anatomy of this joint is detailed.

The patellofemoral joint includes the osseous morphology and its dysplastic variants. More recently, the radiographic image of the osseous morphology of the patella has been shown to be mismatched to the topography of its cartilaginous surface. The primary soft-tissue static stabilizers of the patellofemoral joint are the medial and lateral patellofemoral and patellobital complexes. Patellofemoral function is also dependent on limb alignment, which includes varus or valgus tibiofemoral alignment as well as rotational variances in femoral version. More recently, the relation of the knee to the pelvic position and strength has been added as an important stabilizer of the knee and the patellar elements. This complex orchestration of factors offers challenges to understanding normal, and thus abnormal, patellofemoral joint function. Some forms of patellofemoral arthritis are due to abnormal forces; the challenge is to understand the interplay of the components described above, before advocating corrective measures.

Despite these challenges, it is useful to try to understand patellar malalignment as a clinical entity. The dangers of relating patellar malalignment to a specific single entity, such as an imaged view, is that this can lead to surgery directed at trying to “correct” the alignment without understanding how that image relates to the disease process or the patient presentation. This can create negative consequences for patients, including unnecessary surgery and/or poor results. This concept is eloquently discussed by Post et al., who defined patellofemoral malalignment as “[a] malalignment of forces . . . a concept of imbalance that helps explain patellofemoral disorders . . . Treatment of malalignment must include consideration of all contributing forces.”

Patellofemoral arthritis is defined as the loss of articular cartilage on one or both surfaces of the patella and/or in the trochlear groove. Does malalignment play a role in patellofemoral arthritis? How often is patellofemoral arthritis associated with radiographic evidence of patellofemoral malalignment? This is difficult to discern from the literature. A fair amount of documentation in the literature on patellar arthritis has shown that the greatest prevalence of chondral wear is on the lateral patellar facet as seen both clinically and in autopsy studies. The presence of lateral facet arthritis does not equal malalignment, but it does suggest that the lateral patellar facet becomes overloaded more commonly than the central or medial aspect of the patella. This suggests that there is some degree of tilt or malalignment or maldistribution of force in the etiology of lateral facet arthritis.

With regard to the prevalence of radiographic malalignment in patients managed with patellofemoral arthroplasty, one series of seventy-two knees showed that sixty-one (85%) needed some form of realignment procedure at the time of arthroplasty. Other series of isolated patellofemoral resurfacing arthroplasty have shown that patellofemoral arthritis associated with malalignment was the most common clinical presentation in these patient groups. This suggests that patellofemoral malalignment is a factor in the etiology of some presentations of patellofemoral arthritis. Therefore, a patellar “realignment” procedure might be appropriate to address this form of patellar arthritis.

The goals of patellofemoral realignment surgery are to create both a stable environment for optimal extensor mechanism performance and an appropriate load transmission for optimal cartilage wear and joint loading.

**Soft-Tissue Realignment of the Extensor Mechanism**

Soft-tissue realignment surgery to address cartilage disease in the patellofemoral joint has been described in the literature on patellar instability. More than 150 variations of patellar realignments have been reported. These include proximal procedures, such as releasing or lengthening the lateral retinaculum; imbricating, reattaching, or reconstructing the medial patellofemoral ligament; and/or advancement of the vastus medialis obliquus.

Most distal procedures that involve osseous realignment are based on transferring the tibial tubercle; among the most common such procedures worldwide is the Elmslie-Trillat procedure (medial transfer of the tibial tubercle). Anterior tibial tubercle elevation is discussed separately.

The outcome of soft-tissue patellar realignment for the treatment of patellofemoral pain in the absence of instability is largely unknown. A literature review showed that most reports typically involve mixed groups that have both pain and instability. Most
studies are retrospective. Few have utilized a valid pain scale or a validated functional scale.

The clinical importance of the medial patellofemoral ligament (Fig. 1) in the stability of the patellofemoral joint against lateral patellofemoral dislocation has been well established\(^1\). Reestablishment of the checkrein phenomenon of the medial patellofemoral ligament is an important component of balancing the patellofemoral joint. When imaging studies show evidence of lateral patellar subluxation, some degree of laxity of the medial retinacular structures must be involved. Although subluxation may be evident radiographically, the patient may or may not have lateral tightness on physical examination. Therefore, to realign a patella that has radiographic evidence of subluxation, one would need, at a minimum, to address the soft-tissue patellar restraint provided by the medial soft-tissue restraints, particularly the medial patellofemoral ligament.

Lateral release is a realignment procedure that historically has been widely used for the treatment of anterior knee pain. Studies have shown that the lateral retinacular release relieves anterior knee pain when there is radiographic documentation of pathologic lateral patellar tilt in the absence of patellar instability\(^19,20\). The commonly held belief that a lateral retinacular release causes the patella to move medially is not borne out by biomechanical studies. The vector of the lateral retinaculum is a posterior lateral vector. One study revealed that cutting the lateral retinaculum resulted in a 10% decrease in the lateral restraining force\(^21\). This operation, whether open or arthroscopic, should therefore be used only when there is some tightness or a contracture of the lateral retinaculum that tethers the lateral border to the patella posterolaterally and when this is a source of pain and/or pressure-creating forces in the patellofemoral compartment.

A more specific issue that continues to be debated concerns the concomitant application of arthroscopic débridement and lateral release. Satisfactory results are possible for patients with minimal arthritis of the lateral facet who have patellar tilt and minimal or no subluxation\(^19,20\). In the face of clinically important arthritis, however, it should be understood that débridement and release has limited goals with typically incomplete and unpredictable pain relief and may often be a precursor of more definitive interventions.

In patients with long-standing patellar tilt and malalignment, a tail, or large osteophyte, is often apparent on the lateral aspect of the patella (Fig. 2).

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Fig. 1
Demonstration of the medial patellofemoral ligament in a cadaveric knee specimen.

Fig. 2
Merchant, or skyline, radiograph of the knee showing a large lateral osteophyte in a patient with long-standing patellar tilt and malalignment.
There is support in the literature for excision of this lateral facet, i.e., a partial lateral patellar facetectomy, so to speak, as it may provide limited relief of the symptoms of arthritis of the lateral patellofemoral compartment.

Therefore, the isolated lateral retinacular release in the treatment of patellofemoral arthritis may have some applicability when the following factors are present: (1) lateral patellofemoral arthritis on one or both sides of the patellofemoral joint, (2) radiographic evidence of tilt without subluxation, and (3) no clinical history of instability. Combining this release with a partial lateral facetectomy when there is a large osteophyte may increase its clinical utility.

Caution is required when soft-tissue patellar repositioning techniques are considered for patients with a lesion in the central aspect of the trochlear groove, as there is no evidence to suggest that changing the patellar position, as an isolated procedure, unloads or relieves the contact forces in this region.

There has been renewed interest in the role of soft-tissue realignment in the treatment of patellofemoral chondral wear when it is combined with surgical procedures that address the damaged cartilage. Proximal soft-tissue procedures best address the clinical scenario of a patient with lateral patellar subluxation combined with unipolar lateral patellofemoral compartment arthritis.

**Osteotomies of the Tibial Tubercle**

It stands to reason that removing pressure from an arthritic portion of a joint should allow symptomatic relief. This is the essence of tibial tubercle transfer in the treatment of patellofemoral arthritis. It also forms the basis for other osteotomy-based corrections of patellofemoral malalignment secondary to valgus or rotational deformities, but these are not commonly encountered causes of isolated patellofemoral arthritis. Realignment of the extensor mechanism has been thought to provide relief because of the restoration of normal alignment and mechanical function. An important corollary is often overlooked, however. Realignment by transfer of the tibial tubercle can also unload a fragmented painful surface of the patellofemoral joint. Historically, transfer of the tibial tubercle with operations such as the Maquet and Hauser procedures have met with poor results and are no longer indicated. The Hauser procedure, for example, resulted in late severe osteoarthritis and was an example of procedures based on measurements of abnormality of the tibial tubercle according to the “Q angle.” These procedures, however, did not account for the variability in the normal values of the Q angle or the potential increase in loading of the medial patellar facet (and thus the subsequent possibility of medial tobiopofemoral compartment arthritis) caused by overzealous medial transfer of the tibial tubercle.

The key principles in successful tibial tubercle transfer for the treatment of patellofemoral arthritis are as follows:

1. Restore or maintain proper balance of the extensor mechanism.
2. Transfer load off a painful, degenerated area onto better cartilage. Transfer the tibial tuberosity medially to unload the lateral aspect of the patella and anteriorly to unload the distal aspect of the patella.
3. Be sure to treat retinacular sources of pain.
4. Perform tibial tubercle transfer in a way that allows early motion and prompt healing.

**Selection of Patients for Tibial Tubercle Transfer Osteotomy**

Tibial tubercle transfer in the treatment of patellofemoral arthritis is particularly attractive for younger patients. Buuck and Fulkerson demonstrated long-term success and an increase in activity levels at four to twelve years after anterior transfer of the tibial tubercle. When it is properly done for the right indications, tibial tubercle transfer therefore holds the potential for a permanent solution to patellofemoral arthritis pain and dysfunction related to malalignment. The surgeon must first determine the part of the patellofemoral joint that needs to be unloaded by reviewing the findings of a detailed history, physical examination, radiographs with the knee in 45° of flexion combined with precise lateral views; magnetic resonance imaging scans, and arthroscopy. All of the findings of these studies should correlate. For example, if the patient sustained a dashboard injury or a crush injury of the patellofemoral joint with the knee in flexion, the patellar articular lesion is likely to be proximal since this area articulates with the femur when the knee is flexed.

To select the correct osteotomy, one must understand that moving the tibial tubercle anteriorly shifts contact on the patella such that more proximal patellar articular cartilage comes into contact earlier in the flexion arc. This is highly desirable when there is a distal patellar articular lesion that can be taken out of contact by anteriorization of the tibial tubercle. Most patients with malalignment-related patellofemoral breakdown have lateral and distal articular lesions. Anterior and medial transfer of the tibial tubercle, then, is well suited for the typical patient with malalignment-related patellofemoral breakdown. Pidoriano et al. established that the grade of articular lesion was far less important than the location of a lesion in determining the likelihood of success following anteromedial tibial tubercle transfer.

In patients with malalignment, however, the surgeon may need to compensate additionally for dysplasia of the quadriceps or trochlea. In most such patients, we use proximal retinacular balancing or reconstruction as needed.

Once the location of a pain-producing lesion has been documented, the osteotomy design should be straightforward. If there is a lateral articular lesion and lateral tracking, the patella should be moved medially with use of a Trillat (straight medial) tibial tubercle transfer. If there is a purely distal articular lesion with healthy proximal cartilage with normal alignment (relatively uncommon), a straight anteriorization of the tibial tubercle is most appropri...
ate. If the patella has been overloaded medially from previous surgery and there is medial articular cartilage breakdown, sometimes associated with medial patellar subluxation, anterolateral tibial tubercle transfer may be most appropriate.

The most common presentation that we see is lateral and distal patellar breakdown related to lateral patellar tracking. It is best treated with anteromedial tibial tubercle transfer with use of an oblique osteotomy, tapering to the anterior cortex distally. Anteromedial tibial tubercle transfer may be most appropriate. The surgeon must consider the fact that restoration of the normal alignment of the extensor mechanism reduces chronic retinacular strain around the anterior aspect of the knee and improves function and, therefore, may make future knee joint arthroplasty less complicated.

**Anteromedial Tibial Tubercle Transfer**

An oblique osteotomy behind the tibial tubercle (Fig. 3), tapered to the anterior tibial cortex distally, allows dramatic unloading of the lateral and distal aspect of the patella while restoring proper tracking of the extensor mechanism. This procedure is performed through a longitudinal incision; the osteotomy is cut from anteromedial to posterolateral, starting adjacent to the medial aspect of the tibial tubercle, preferably with use of a cutting slot guide (Fig. 4). It is imperative that the osteotomy be monitored as it exits the lateral tibial cortex. This is accomplished by retracting the anterior tibial muscle. This lateral cut is then connected to a transverse cut proximal to the tibial tubercle, and the osteotomized fragment is shifted anteriorly and medially along the osteotomy plane. The transferred tibial tubercle is then fixed securely with two cortical lag screws so that the patient can start early motion. It is the procedure of choice for distal and lateral patellofemoral arthritis related to chronic patellofemoral malalignment (Fig. 5). Blood loss is minimal with this type of surgery, incisional pain is less severe than that following knee arthroplasty (since the incision is pretibial instead of peripatellar), and immediate motion is possible (and encouraged). Skin problems and compartment syndrome have not been noted following transfer of the tibial tubercle through a flat, oblique osteotomy. Osteotomies are less desirable in patients who smoke, are grossly obese, or are diabetic, but they are attractive for younger patients for whom longevity is expected.

Anteromedial tibial tubercle transfer is an important adjunct to patellofemoral resurfacing procedures. The surgeon must decide when unloading with an anteromedial transfer of the tibial tubercle is sufficient in the treatment of an articular lesion. Selectively, autologous or allograft osteochondral core transfer may be a helpful adjunct, particularly on the trochlear side.

To maximize the likelihood of a successful tibial tubercle transfer, the surgeon must create a precise osteotomy, tapered to the anterior cortex distally, to avoid creating a stress-riser in the tibia. Fixation must be secured with cortical lag screws. Early range of mo-
tion is very important in these patients, but weight-bearing must be protected for at least six weeks as Stetson et al. showed a higher rate of tibial fracture with immediate weight-bearing. A more recent study has shown that tibial fracture is more likely if the tibial osteotomy creates a distal stress-riser. In other words, technical precision is of paramount importance in achieving an optimal result. Of course, transferring load onto healthy articular cartilage and off diseased, painful cartilage is the goal of this type of surgery.

When patellofemoral changes are diffuse, as in a crush injury or following patellar fracture, patellofemoral replacement may become necessary. In general, however, anteromedial transfer of the tibial tubercle is the best option in a young patient with distal and/or lateral patellar articular lesions, even when there is bone on bone laterally.

**Autologous Chondrocyte Implantation**

When autologous chondrocyte implantation is being considered for the repair of a cartilage defect, it is critical that the etiology and the underlying cause or abnormal pathomechanics of the defect are accurately identified. The diagnosis and correction of these underlying abnormalities are crucial to a successful outcome with autologous chondrocyte implantation. It is now clear that a failure to fully appreciate this point explains the disappointing early results of resurfacing of the patella. In a study from Sweden published in 1994, autologous chondrocyte transplantation was successful (a good or excellent result) in only two of seven patients. However, in later reports, in which patellar tracking was also addressed with realignment of the extensor mechanism at the time of transplantation, eleven of seventeen patients had a good or excellent result at two years and this improved to thirteen of the seventeen patients at ten years. The importance of correcting the underlying cause of the chondral injury cannot be underestimated.

As previously mentioned, Pidoriano et al. demonstrated that with the anteromedial tibial tubercle osteotomy, a successful clinical outcome correlates with the location of the patellar articular lesion. Patients with type-I (inferior pole) or type-II (lateral facet) lesions were substantially more likely to have a good or excellent result than were those with type-III (medial facet) or type-IV (proximal pole or diffuse) lesions. Central trochlear lesions were associated with medial patellar lesions, and these patients had a poorer result.

Localization of the articular cartilage injury at the time of reconstruction is therefore important to determine whether osteotomy alone may predict a successful outcome. Despite the mediocre results to date, as discussed above, cartilage repair of patellar type-III and IV lesions, as well as trochlear lesions, may still be useful in improving the clinical outcome for these difficult lesions when they are associated with patellar maltracking or when there is normal tracking but no other options exist.

**Clinical Evaluation and Technical Considerations in Autologous Chondrocyte Implantation**

Autologous chondrocyte implantation is indicated in the management of focal chondral defects in the knee. The cartilage space must be documented as intact on standard radiographs, to indicate that the overall joint space is patent, the margins are well shouldered, and the cartilage loss is not diffuse, but contained.

The standard workup for these patients includes a thorough review of the history and a careful physical examination of the axial alignment as well as the patellofemoral joint. A routine series of radiographs is made for all patients; these include standing anteroposterior, 45° posteroanterior flexion weight-bearing (Rosenberg), lateral, and skyline (Merchant) radiographs and a 54-in (1.37-m) axial alignment radiograph. When maltracking is suspected on clinical examination, a computed tomography scan is performed, with the leg in extension and with and without quadriceps contraction, to assess lateral patellar subluxation, the presence of dysplasia of the trochlea, and patellar height. Correction of any underlying pathomechanic disorder that is identified can thus be planned in combination with the cartilage repair.

When a patient is considered a candidate for autologous chondrocyte implantation, arthroscopy is performed to assess the diameter and depth of the lesion and any maltracking. A cartilage biopsy specimen is also obtained from the non-weight-bearing portion of the superior intercondylar notch at this point for the cell culture process. Approximately 200 to 300 mg of articular cartilage is sent in a sterile transport medium to be commercially cultured and cryopreserved. The transplantation procedure is then performed as previously described. Technical issues that are specific to autologous chondrocyte implantation in the patellofemoral joint include a suture technique that restores the articular surface shape of the patella and the trochlea (Fig. 6) as well as a soft-tissue tensioning at the end of the procedure that allows the normal medial-to-lateral and proximal-to-distal patellar glide without...
overstuffing the patellofemoral joint.

We believe that the factors that determine the success of cartilage repair include alignment and tracking, joint stability, chondral defect size, the integrity of the menisci, and finally the patient’s predisposition to osteoarthritis as evidenced by poor-quality articular cartilage. Hence, if there is ≥2° of mechanical malalignment from a neutral mechanical axis in the tibiofemoral joint in combination with a large chondral defect, then a varus or valgus-producing osteotomy should accompany the cartilage repair on the weight-bearing condyles. If there is evidence of patellar subluxation and tilt on clinical examination and/or computed tomography, then an anteromedial tibial tubercle transfer is performed in combination with resurfacing of the patella or trochlea, or both.

The principles of postoperative therapy include functional rehabilitation that avoids resisted open-chain activities. Rehabilitation in the first six weeks includes restoration of the tibiofemoral range of motion as well as patellar mobility to prevent infrapatellar tendon contracture. This is accomplished with aggressive deep friction, mobilization, and stretches as well as continuous passive motion for six weeks postoperatively and stationary bicycle use beginning at four weeks. Muscle tone is reestablished with isometric leg lifts, muscle contractions, and stationary bicycling. As the patella and trochlea experience maximal contact forces between 40° and 70° of flexion, open-chain quadriceps extensions through this range of motion are avoided.

Results of Autologous Chondrocyte Implantation

Minas and Bryant1 performed a seven-year, prospective cohort study of forty-five patients who underwent autologous chondrocyte implantation for the treatment of full-thickness chondral defects of the patella or trochlea, or both. The average age of the patients at the time of surgery was 36.9 years (range, fifteen to fifty-four years). The average duration of follow-up was 47.5 months (range, twenty-four to eighty-six months). A patient survey showed that 71% were satisfied with the outcome, 16% were neutral, and 13% were dissatisfied. Eighty-seven percent of the patients said they would choose the surgery again. Overall, 71% of the patients rated the results as good to excellent; 22%, as fair; and only 7%, as poor. The largest improvement in sports activity rating, surprisingly, was for the patients with the most severely injured knees.

Large clinical improvements at a significant level were documented with use of the Short Form-36 (SF-36), the Knee Society score, the Western Ontario and McMaster University Osteoarthritis Index (WOMAC), and the modified Cincinnati knee score (Table I).

Twenty-nine (64%) of the forty-five subjects required an osteotomy for the treatment of tibiofemoral or patellofemoral malalignment, or both. The osteotomy effect alone would not account for the high success rate, according to the results described by Pidoriano et al.7, because of the size and location of these chondral defects.

Typically, patients start to have pain relief by four to six months after surgery. Non-impact sports activities are commenced at nine months postoperatively, and full-impact activities are begun by eighteen months postoperatively. Maximal improvement may take as long as three years for patients who have large areas of chondrocyte implantation, as additional time is needed for graft maturation.

The graft failed in eight patients (18%). Of the eleven patients with a Workers’ Compensation claim, five had a graft failure. Failure of the graft was considered a partial or full failure (which was evidenced by delamination or detachment of the graft from the adjacent cartilage and subchondral bone as seen at arthroscopy or on magnetic resonance imaging, or as evidenced by fibrous or fibrocartilage repair) regardless of a good clinical outcome. These results are similar to those found by Peterson et al., who addressed patellar maltracking at the time of surgery or corrected it prior to the time of autologous chondrocyte implantation.1 The results in their patients remained durable for up to ten years after implantation. These are excellent outcomes for patients with difficult problems.

The data in the study by Minas and Bryant showed that when type-III and IV chondral injuries to the patella

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Fig. 6

Intraoperative photograph of autologous chondrocyte implantation in a trochlear lesion (arrow), demonstrating the important technical point of restoring the contour of the articular surface.
as well as the central part of the trochlea were resurfaced, patients had good clinical pain relief and improved function regardless of whether there had been preexisting patellofemoral maltracking requiring a Fulkerson osteotomy. Autologous chondrocyte implantation remains the treatment of choice for disabling anterior knee pain resulting from large erosive chondral defects (4 to 6 cm² on the average) when the radiographic joint space remains intact. However, when collapse of the joint space can be seen on the Merchant or skyline radiograph, cartilage repair with autologous chondrocyte implantation is no longer possible. The procedure relies on intact, full-thickness cartilage margins to maintain the joint space so that the growing cartilage repair tissue may fill the defect. With joint space collapse, a unicompartmental patellofemoral or total knee arthroplasty may be considered.

Patellofemoral Replacement

The patellofemoral joint is susceptible to both primary osteoarthritis and secondary osteoarthritis because of the large forces transmitted across small contact areas and the high prevalence of anatomical abnormalities or dysplasia. Patellofemoral dysplasia is increasingly recognized as the underlying cause of multiple symptoms within the patellofemoral articulation, such as dislocation and painful instability, and it often results in secondary osteoarthritis if not reconstructed.

The first report of a patellofemoral replacement, to our knowledge, was the McKeever screw-on Vitallium patellar shell, which was introduced in 1955⁴². The designs evolved through various materials until 1979, when the Lubinus patellar glide, or total patellofemoral replacement, was reported⁴³. Patellofemoral arthroplasty has the po-

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<th>Mean Postop. Score (points)</th>
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*WOMAC = Western Ontario and McMaster University Osteoarthritis Index.

Fig. 7-A, 7-B, and 7-C Images of an Avon patellofemoral joint replacement in situ. **Fig. 7-A** Anteroposterior radiograph. **Fig. 7-B** Lateral radiograph. **Fig. 7-C** Sunrise radiograph.
tential advantages of retaining the menisci and cruciate ligaments and thereby the natural kinematics of the knee joint; however, the shortcoming of this procedure to date has been the durability of the arthroplasty. Previous cohort studies of several different patellofemoral designs have described indifferent results. For example, in a study of seventy-six knees, the Lulubin prosthesis had a failure rate of 50% at eight years. The main reasons for failure have been persistent malalignment, wear, impingement, and disease progression.

However, better results are emerging with the Avon patellofemoral replacement (Stryker Orthopaedics, Limerick, Ireland), which is specifically designed to address the reasons for failure described above (Figs. 7-A, 7-B, and 7-C). The design of the Avon replacement is based on the patellofemoral compartment of the Kinemax Plus total knee replacement (Stryker Orthopaedics). The femoral flange is shallow and broad, allowing unconstrained capture of the patella into a deeper trochlea with flexion. The patellar button is offset and uniquely chamfered on its medial side to create an odd facet and broad, allowing unconstrained capsular motion adjacent to the patella with femoral articulation. The functional results in these patients are similar to those after a total knee replacement.

The results to date suggest that this improved design has potentially eliminated the previous problems of malalignment and early wear. The patients had a low rate of complications and an excellent range of movement. Disease progression in the tibiofemoral joint remains a potential problem. This type of prosthesis offers a reasonable alternative to total knee replacement in patients with isolated patellofemoral disease, particularly in those who are considered too young for a total joint replacement. The use of patellectomy in these younger patients has been associated with poor results and failure in up

| TABLE II Results for 307 patients at Five Years After an Avon Patellofemoral Replacement* |
|---------------------------------|----------------|----------------|----------------|
|                                | Mean Bristol Pain Score¹² | Mean Bartlett Patellar Score¹⁴ | Mean Oxford Knee Score¹³ |
| All Patients                   |                          |                              |                           |
| Preoperative evaluation        | 15                       | 10                           | 19                        |
| Five-year follow-up visit      | 36                       | 30                           | 39                        |
| Patients who were fifty-five years old or less | 5                       | 10                           | 18                        |
| Preoperative evaluation        |                          |                              |                           |
| Five-year follow-up visit      | 40                       | 30                           | 42                        |

*The maximum score was 40 for the Bristol pain-rating system, 30 for the Bartlett patellar rating system, and 48 for the Oxford knee-rating system.
to 47%, with variable amounts of pain relief, substantial loss of power, instability, and extensor lag reported. One important variant to remember, however, is the potential role of anteromedial transfer of the tibial tubercle in knees with isolated lateral facet lesions, as the procedure has been associated with good results, even in knees with advanced (bone-on-bone) disease. Current indications for patellofemoral arthroplasty, therefore, include isolated patellofemoral disease with minimal or no malalignment in a younger patient who would otherwise consider undergoing a patellectomy because of the severity of the symptoms.

**Total Knee Arthroplasty**

Although in some respects counterintuitive, the use of total knee arthroplasty for the treatment of isolated patellofemoral arthritis has recently been confirmed as an effective method of oral arthritis has recently been confirmed for the treatment of isolated patellofemoral arthritis. Although in some respects counterintuitive, the use of total knee arthroplasty therefore, include isolated patellofemoral disease with minimal or no malalignment in a younger patient who would otherwise consider undergoing a patellectomy because of the severity of the symptoms.}

Careful adherence to correct techniques and component alignment are well recognized as being crucial to the success of any total knee arthroplasty. These issues are of even more critical importance in the treatment of isolated patellofemoral disease and its typical association with abnormal mechanics and alignment. Particular attention must be directed toward the correction of extensor mechanism alignment, and, indeed, it has been found that the rate of lateral retinacular release in these patients is as high as 68%, which is as much as three times that in standard total knee arthroplasty. The same investigators also reported that the rate of proximal extensor mechanism realignment was 10% in this patient group.

Although the technique of total knee arthroplasty for patellofemoral disease is, in essence, the same as that for tricompartmental disease—leaving aside the debate as to whether the patella should be routinely resurfaced—the procedure is typically a more challenging technical undertaking for patellofemoral disease, and some points merit emphasis. It is critical to avoid internal rotation and medialization of both the tibial and femoral components. Well-described landmarks such as the epicondylar axis, axis of Whiteside, posterior condyles, and the tibial tuberosity should all be carefully checked to ensure that there is adequate external rotation and lateralization of these components to facilitate accurate patellar tracking. Excessive femoral varus and oversizing of the femoral component are also to be avoided for the same reasons. The patellar component itself should be medialized for greatest stability. It is also important to achieve an evenly resected patellar surface, parallel to the nonarticular surface, to accommodate the patellar component. This avoids a lack of congruity, tilting, and thus maltracking of the prosthetic patellofemoral articulation. It is, however, important to be aware of the potential for exaggerated thinning of the lateral facet in these knees; a degree of controlled under resection of this facet may be required to maintain adequate bone stock. Restoration or maintenance of the native joint line is also important, and the creation of an overly thick or thin patellar construct is to be avoided.

Once the components have been selected, a trial reduction and assessment of tracking (we prefer the use of the so-called no-thumbs technique of Insall) is vital. As stated above, a higher rate of lateral release in these knees can be anticipated. In cases in which a retinacular release is necessary, we preserve the distal (tibial) attachment of the fat pad and release the proximal (patellar) attachment. The proximal pole of the fat graft is then transposed laterally to close the gap created by the retinacular release. We believe that this serves two purposes: (1) it minimizes the severity of vascular injury to the patella, and (2) it minimizes the formation of subcutaneous hematoma and postoperative drainage. It is noteworthy in this regard that lateral release has been reported to increase the prevalence of patellar fracture from 15% to >50% overall. Although implant design considerations and their impact on patellofemoral kinematics are somewhat outside the scope of this report, issues to be cognizant of include the dimensions and symmetry of the trochlear groove, the congruence of the femoral and patellar components, and the symmetry of the patellar component itself.

Results with total knee arthroplasty for the treatment of patellofemoral arthritis have been very good and are associated with reliable pain relief. Admittedly, three main reports on this
management approach have noted a high rate of residual postoperative patellar tilt, asymmetrically resurfaced patellae, and residual subluxation\textsuperscript{17-19}, reflecting the technical complexity inherent in these cases. Nonetheless, the patients in those studies achieved uniformly good-to-excellent results in terms of pain relief, results that were superior to those achieved by comparison groups that had total knee arthroplasties performed for other conditions. Although preoperative anterior knee pain was more prevalent in the patients with patellofemoral arthritis than in those with tricompartmental arthritis, equal numbers of patients reported residual anterior knee pain following total knee arthroplasty\textsuperscript{5,7,13,42,48}. Also, despite the fact that the ability of patients with patellofemoral arthritis to climb stairs preoperatively was less than that of patients with tricompartmental disease, postoperatively the patients with patellofemoral arthritis had a greater ability to climb stairs in a bipedal manner and had higher Knee Society scores\textsuperscript{3}.

The debate regarding the use of this procedure currently centers on the fact that it can appear that a tricompartmental arthroplasty is an excessive response to a unicompartamental condition. Although more conservative approaches, in particular patellofemoral arthroplasty (which has had increasingly encouraging results), would be theoretically more satisfactory, total knee arthroplasty currently remains the most proven and predictable single procedure in this specific population of older patients with patellofemoral disease\textsuperscript{5,7,13,42,48}. Total knee arthroplasty, therefore, remains a reasonable option for these patients until its reliably excellent results can be equaled by other interventions.

**Overview**

It is clear that there is a complex spectrum of patellofemoral disease often culminating in arthritis. There is a correspondingly wide array of management options, depending on the exact nature of the disease in an individual. This complexity dictates that, when a patient who has anterior knee pain is seen, a determination of the precise etiology is essential. It is only through an accurate identification of the problem that the correct treatment modality can be established. The importance of determining the etiology has been emphasized throughout this symposium, and we have presented current viewpoints regarding the appropriate treatment modalities depending on the nature of the patellofemoral disease encountered.

Although its role is still not fully defined, patellar malalignment has been shown to be an important factor in the etiology of patellofemoral arthritis. Most care is required, however, in determining how malalignment relates to the disease process or the painful situation in an individual patient in order to ensure appropriate surgical interventions. Procedures strictly involving soft tissue, such as isolated lateral retinacular release, can have a useful if somewhat limited role in the treatment of patellofemoral arthritis. Such procedures are particularly suited to patients with lateral patellar subluxation combined with unipolar lateral patellofemoral compartment arthritis, but they should be avoided when there is a lesion in the central part of the trochlear groove.

Tibial tubercle transfer has proven to be very successful for patients with patellofemoral arthritis who still possess healthy cartilage onto which the patellar tracking can be transferred. As with all procedures for the treatment of patellofemoral disorders, the results depend on proper patient selection and the proficiency of the surgeon. It is important to be aware of the correct indications for this procedure and to be proficient in the technical aspects of its performance in order to obtain satisfactory outcomes free of complications. The great advantage of the tibial tubercle transfer is that it can provide a permanent solution for the pain and dysfunction associated with malalignment-related patellofemoral arthritis. This is particularly important when considering younger patients who may have more limited treatment options than their older counterparts.

Cartilage resurfacing also represents a very promising treatment option with the potential for long-term resolution of disease and symptoms, which may be particularly advantageous in younger patients. The ultimate goal of this approach, in combination with tibial tubercle transfer, is to supplant the need for patellectomy or arthroplasty in younger patients with relatively early disease. Again, careful adherence to patient selection criteria and accurate technical performance are crucial to the success of autologous chondrocyte implantation. Substantial improvements in the understanding and technique of this procedure in the patellofemoral articulation have led to improved results and more reliable outcomes. Once established, this technique may become the treatment of choice for large, erosive chondral defects associated with disabling anterior knee pain.

As with other procedures described in the present report, patient selection is critical to the success of patellofemoral arthroplasty. A candidate for the procedure should have isolated patellofemoral disease, which is noninflammatory, and should have no substantial maltracking. Although ideally there should be no tibiofemoral disease, the presence of grade-III chondromalacia in the tibiofemoral articulation is a definite contraindication. With the improvements in the results currently being reported, patellofemoral arthroplasty may be a solution for younger active patients with debilitating disease who would otherwise be candidates for patellectomy. Prosthetic design is critical to success, and there is currently a need for high-quality, long-term prospective data to define the role of patellofemoral arthroplasty.

It seems increasingly likely that, with the improving results of modern patellofemoral arthroplasty and alternative procedures, the use of total knee arthroplasty for the treatment of patellofemoral arthritis will eventually be outmoded. For the moment, however, these alternatives do not provide rates of consistently excellent pain relief and functional improvement that are equal to those achieved with total knee ar-
throplasty in the older patient population. There are important technical challenges in applying total knee arthroplasty to these patients, and the procedure is not recommended for younger patients.

Despite the progress in the treatment of patellofemoral arthritis, it remains difficult to achieve absolute unanimity on the best course of treatment for a given patient. As more evidence is obtained from good-quality, prospective, long-term clinical studies with regard to both the etiology and management of this disease, we can anticipate increasing agreement on these issues. Such studies, though, have traditionally proven difficult to perform and by their nature take some time to come to fruition. This is a microcosm of many of the issues faced in current orthopaedic practice, in which definitive evidence often lags behind clinical developments. What is needed is information regarding which patients with maltracking or anterior knee pain will progress to arthritis and thus would benefit from early, less aggressive interventions. When arthritis does occur, we need to know which patients are best suited to the current management options through long-term outcomes analysis. Specific controversial and topical areas that can be expected to profit from better evidence include the relative roles for chondral reconstruction, redirection osteotomies, and patellofemoral arthroplasty.

Therefore, although the treatment of patellofemoral arthritis is not fully resolved, there are currently many exciting areas of progress. These advances offer considerable promise that this previously poorly managed spectrum of disease will ultimately prove amenable to a defined set of graduated interventions, thus ensuring satisfactory symptomatic and functional outcomes for our patients.

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