Distal Realignment for Patellofemoral Disease

Jack Farr, MD

Although the emphasis of this chapter is on tibial tuberosity surgery for patellofemoral disease, the multifactorial nature of patellofemoral dysfunction requires an acknowledgment that a patellofemoral problem is rarely addressed by a single surgical treatment. Tibial tuberosity repositioning must be examined with a full appreciation of proximal soft tissue balance, limb rotation, and articular cartilage disease (grade, site, and extent). Although positive outcomes were initially reported for many distal realignment patellofemoral surgeries, early positive results often deteriorated markedly over time. In the case of the Hauser posterior medial tuberosity transfer, although stability was maintained, patellofemoral cartilage degeneration predictably occurred over time. Thus, in general, patellofemoral surgery not only must address the acute problem but do so without causing intermediate and long-term problems, such as chondrosis and arthrosis. Application of a more scientific approach to patellofemoral dysfunction has led to the identification of the importance of the medial patellofemoral ligament (MPFL) in restraint to lateral patellar instability, and it has refined and focused the limited role of lateral release to isolated, documented patellar tilt rather than global patellofemoral pain or instability. Likewise, the role of tibial tuberosity surgery for patellofemoral dysfunction continues to evolve both as an isolated procedure and in conjunction with proximal patellofemoral surgery.

Indications espoused for tuberosity surgery (often in combination with proximal soft tissue surgery) at one point included patellofemoral pain, instability, chondrosis, and arthrosis. Straight tibial tuberosity medialization (TTM) was initially associated with the names of specific surgeons, including Roux, Elmslie, and Trillat; anteriorization, with Maquet; and anteromedialization (AMZ), with Fulkeron. These tuberosity surgeries have, at times, been used to treat static patellar subluxation, recurrent lateral patellar instability, patellar pain, and patellofemoral chondrosis. Tuberosity surgery for treatment of recurrent or chronic patellofemoral dislocation or subluxation was based on the assumption that the primary pathologic process was an increased Q (quadriceps) angle; for pain and chondrosis, elevation was promoted as the preferred procedure to dramatically decrease patellofemoral stress. Whereas it is obvious that repositioning of the distal point of the Q angle (tibial tuberosity) surgically does modify the Q angle, today the MPFL is accepted as the main restraint to lateral patellar instability. In fact, the Q angle, which formed the rational basis for planning of a TTM, is being questioned as a benchmark in light of the poor intraobserver and interobserver reproducibility of the measurement as reviewed by Post. In addition, Fithian is questioning the role of TTM for lateral patellar instability. At the annual meeting of the American Orthopaedic Society for Sports Medicine in 2005, he presented a case series of recurrent lateral patellar instability treated by MPFL reconstruction with or without TTM. The results were the same in both groups. On the other hand, it must be acknowledged that Cox has reported excellent long-term results in prevention of recurrent patellar instability with TTM, although critics note that his report is a clinical outcome series without radiographs that might have demonstrated arthrosis (as predicted to occur with
excessive medialization of the tuberosity in biomechanical studies by Andrisch and Kuroda). Furthermore, as the extent of medialization with TTM has been variably defined, critics could imply that (1) some of the patients with instability successfully treated by TTM had spontaneous healing of the MPFL, (2) the MPFL lesion was marginally injured, or (3) the TTM "overmedialized" the tuberosity and constrained the patella into stability.

From a basic science approach, the initial tuberosity surgery focused on the action of the various force vectors on patellar position and motion and on the effect of tuberosity position on those vectors. However, the equation is more complicated, as Teitge, Powers, Heino, and others have emphasized the importance of the "other half" of the joint in motion; the trochlea and associated tibiofemoral torsion. Furthermore, Dejour has brought to attention the importance of trochlear morphologic features (dysplasia) in patients with lateral patellar instability. In an attempt to objectify tuberosity surgery, we must define normal and abnormal positions of the tuberosity. We must additionally consider the extent of femoral internal torsion and tibial external torsion as per Teitge and Heino.

This objective approach to limb coronal and axial alignment from hip to ankle also measures (at the knee) an objective alternative to the Q angle, that is, the tubial tuberosity to trochlear groove (TT-TG) distance (Fig. 74-1). The TT-TG distance, as popularized by Dejour, quantitates the concept of tibial tuberosity malalignment locally at the knee. Studies suggest that a TT-TG distance of more than 15 to 20 mm is abnormal; most asymptomatic patients have distances that are less than 15 mm. Likewise, anteriorization was first shown mathematically to reduce patellofemoral stress, but direct measurements with pressure-sensitive film, real-time pressure transducer arrays, and finite element analysis modeling such as by Cohen and Ateshian show that although stresses are typically reduced with anteriorization, there is a unique response for each knee, and a global"50%" force reduction cannot be assumed. Thus, load transfer should play an important role in surgical planning, rather than assuming that there will be an absolute decrease in stress. By use of these and other objective parameters, future studies may objectively quantify the preoperative pathologic process to aid in planning of tuberosity surgery.

Preoperative Considerations

History

Subgroups considered for tuberosity surgery are those with static subluxation of the patella, those with patellofemoral chondrosis that requires load optimization, and those with recurrent lateral instability with or without static subluxation. The history will be highly variable for each subgroup, from insidious onset of patellofemoral pain to pain that began after a patellar instability episode. The standard patellofemoral history as outlined by Post should be elicited. Functional aspects need to be documented, including the amount of energy needed to cause instability and the degree of stress necessary to cause pain. Prior surgical operative notes are useful, as are intraoperative photographs.

Typical History
- Failure of prolonged appropriate physical therapy and bracing
- Patellofemoral area pain with prolonged flexed knee position, stairs, or squats
- Giving way with either pain or patellar instability
- Patellofemoral crepitation and intermittent effusion and occasional loose bodies
- Often prior chondroplasty and lateral release

Signs and Symptoms

Patellofemoral symptoms are ubiquitous but nonetheless must be documented as to functional impairments with respect to pain, crepitation, swelling, giving way, and frank patellar instability and loose body sensations. Clinical signs overlap with the physical examination findings and include documentation of crepitation during the specific arc of motion, effusion, and loose body appearance.
Physical Examination

As for all patients with patellofemoral dysfunction, a standard examination is performed of the knee and the entire functional kinetic chain from the pelvis to the foot. A standard patellofemoral examination as detailed by Post pays particular attention to the following:

- Focal site or sites of maximal pain (especially at prior scars) or diffuse pain with any touch (to suggest chronic regional pain syndrome; see contraindications)
- Patellar displacement (measured in trochlear quadrants)
- Patellar height (normal, infera, alta)
- Tuberosity position relative to center of trochlea (Q angle less reliable)
- Limb rotation (femoral and tibial internal and external rotation)
- Muscle bulk and strength, with attention to vastus medialis obliquus
- Patellar tracking through active and passive range of motion
- Individual variations of adequacy of the MPFL
- Patellar tilt or extent of eversion, especially with prior lateral release
- Patellar crepitation (document angle of flexion at which this occurs)
- Apprehension: classic lateral versus global versus medial
- Fulkerson medial instability test

Imaging

Radiography

- Standard weight-bearing anteroposterior and true lateral views
- Shallow flexion angle axial view (i.e., Merchant view)
- Long limb alignment to evaluate coronal limb malalignment
- Rosenberg (skier’s) weight-bearing posteroanterior view

Other Modalities

Magnetic resonance imaging with or without contrast enhancement will add information about the extent and position of articular cartilage disease. Magnetic resonance imaging or computed tomography delineates patellofemoral morphologic features (extent of dysplasia), evaluates congruity of the patella in the trochlea, and provides objective measurement of the TT-TG distance and patellar height—with the understanding that cartilage contour does not always match bone contour.

Technetium bone scan may indicate areas of overload and arthritis or suggest complex regional pain syndrome (sympathetically mediated pain).

Indications and Contraindications

Indications for Tibial Tuberosity Medialization

- Objective measurement of an increased TT-TG distance and symptoms, which can be directly related to abnormal stress secondary to resultant force vectors. The joint has normal or nearly normal articular surfaces of the patellofemoral compartment.
- Objective measurement of a markedly increased TT-TG distance in patients undergoing MPFL reconstruction or repair in an effort to decrease abnormal stress to the MPFL.
- Potentially, those patients with the diagnosis of static chronic patellar subluxation, in addition to recurrent patellofemoral instability, who are undergoing MPFL surgery. In this case, TTM is performed in an effort to improve patellofemoral joint congruity, thus improving contact area, which may decrease stress.
- Objective measurement of an increased TT-TG distance in a patient who has undergone patellofemoral arthroplasty that demonstrates chronic patellar subluxation after correct implantation and adequate lateral release and MPFL repair or reconstruction

Indications for Anteromedialization

- As for TTM, but with chondrosis in the distal lateral region of the patella with an intact trochlea or minimal trochlear chondrosis. (Restated, this includes excessive lateral compression with tilt, chronic static patellar subluxation, and a combination as described originally by Fulkerson.)
- As in the preceding, but with more extensive chondrosis (grade, distribution, and trochlear condrosis). AMZ may be combined with cartilage restoration procedures, when AMZ can decrease stress to the restored regions.

Contraindications to Tibial Tuberosity Medialization

- Normal TT-TG distance
- Abnormal femoral anteverision or tibial torsion as per Teigre
- Problem not explained by an increased TT-TG distance
- Medial patellofemoral chondrosis that would be subjected to increased loading after TTM
- Grade III or higher (Outerbridge or International Cartilage Repair Society) chondrosis of the patella or trochlea
Standard contraindications to knee osteotomy, such as nicotine use, nonspecific pain, infection, inflammatory arthropathy, marked osteoporosis (which would compromise fixation), complex regional pain syndrome, patella infera, and arthrosis.

- Relative contraindication in the markedly varus knee that could have increased stress to the medial tibiofemoral compartment after TTM as per Andrish.

**Contraindications to Anteromedialization (without cartilage restoration)**

- As for contraindications to TTM and when AMZ would be expected to increase the stress in areas of damaged cartilage (e.g., proximal patellar pole after impact chondrosis, diffuse mid-waist patellar chondrosis, or medial facet chondrosis).
- Trochlear chondrosis of grade II or higher.

**Surgical Planning**

The goal of medialization is normalization of the tuberosity position rather than overmedialization, so preoperative radiographic or clinical assessment of TT-TG distance is useful in planning.

**Concomitant Procedures**

If lateral release and MPFL repair (or reconstruction) are performed in conjunction with TTM or AMZ, the procedure order is lateral release, then tuberosity surgery, and finally MPFL surgery. If cartilage restoration is planned, in addition to the TTM or AMZ, these procedures can be performed concomitantly to reduce total knee exposure to surgery and to ease the patient's rehabilitation.

**Surgical Techniques**

**Anesthesia and Positioning**

The less invasive TTM can be performed under local anesthetic with sedation. TTM as well as AMZ may be performed by use of regional blocks (femoral and sciatic), with postoperative femoral nerve block for prolonged pain control. Alternatively, epidural, spinal, or general anesthetics may be used according to the surgeon's preference. Both AMZ and TTM are performed with the patient in the supine position, often with a roll under the ipsilateral pelvis to decrease external rotation. In light of bone surgery, they are often performed with the foot of the operating table elevated and a side post used for the arthroscopic portion of the procedure rather than with the foot in a dependent position.

**Surgical Landmarks, Incisions, and Portals (Fig. 74-2)**

**Landmarks**

- Patella
- Trochlear margins
- Patellar tendon attachment to tibial tuberosity
- Gerdy tuberosity
- Crest of tibia

**Portals and Approaches**

- The arthroscopic portion of the procedure is performed through standard anteromedial and anterolateral portals with the option of an additional proximal portal to view patellar tracking in the trochlea.
- For the isolated TTM, a longitudinal 5-cm incision is made lateral to the tibial tuberosity.
- AMZ is performed either through an oblique 12-cm incision from the anterolateral portal to the midline distally or directly in the midline beginning 2 cm proximal to the patellar tendon attachment to the tibial tuberosity and continuing distally.

**Structures at Risk**

- Anterior tibial artery
- Deep peroneal nerve
- Patellar tendon
- Sites of long-term overload (leading to chondrosis).
Examination Under Anesthesia and Diagnostic Arthroscopy

Under anesthesia, range of motion (comparison of passive patellar tracking to known preoperative active) and the full extent of patellar displacement and tilt are documented. Diagnostic arthroscopy allows mapping and grading of all areas of chondrosis. These findings enter into final planning and in some instances suggest cancellation of the tuberosity surgery in light of discovery of a contraindication.

The arthroscopic examination documents the associated tibiofemoral and patellofemoral chondral (grade and region of lesions) and morphologic features of the pathologic process. This information allows fine-tuning of the tuberosity surgery for the indications listed before. Arthroscopic chondral treatment may be performed as indicated, followed by titration of the lateral release, if necessary. For those patients with reversible patellar tilt and significant medial patellar displacement (two trochlear quadrants), a lateral release will not be performed; for patients with patellar tilt and minimal medial patellar displacement (one trochlear quadrant or less), a limited lateral release or stepcut lateral lengthening will be titrated to allow reversal of tilt and to achieve two quadrants of medial patellar displacement.

Specific Steps (Box 74-1)

Tibial Tuberosity Medialization (Fig. 74-3A and B)
1. Exposure
The skin incision is based on whether the TTM is an isolated or combined surgery. The standard longitudinal

<table>
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<th>Box 74-1 Surgical Steps</th>
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<tr>
<td>1. Exposure</td>
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<td>2. Planning of the osteotomy</td>
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<tr>
<td>3. Performance of the osteotomy</td>
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<td>4. Tubercle fixation</td>
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Figure 74-3 A, Overview of tibial tuberosity medialization.
Figure 74-3, cont'd B. Overview of anteromedialization. C. Orientation of the oblique AMZ osteotomy (left) and of the flat osteotomy of TTM (right).
incision is made lateral to the tibial tuberosity, with approximately 2 cm of the incision above the tuberosity and 3 cm of the incision below the tuberosity. It may be modified to a more universal direct anterior longitudinal approach as dictated by concomitant surgery. The patellar tendon is identified, and the lateral release (if it is performed) is extended along the lateral border of the patellar tendon with emphasis on hemostasis. A 1.5-cm subperiosteal exposure of the lateral aspect of the tibial tuberosity is performed.

2. Planning of the Osteotomy
The coronal plane cut is referenced from the anterior joint lines to be flat in the coronal plane. If there is a desire to unload the distal lateral patella, the cut is made with a mild anteriorly directed slope (Fig. 74-3C, right).

3. Performance of the Osteotomy
A 1.5-cm-deep cut in the axial plane is performed just proximal to the protected patellar tendon proximal attachment to the tibial tuberosity. A second bone cut begins at the posterior aspect of this cut and extends distally for approximately 5 cm while remaining 1.5 cm posterior to the crest of the tibial tuberosity. With the distal anterior tibial crest kept intact, the tuberosity is rotated medially, making a greenstick fracture at the distal portion of the osteotomy. The tuberosity is medialized to the extent that the TT-TG distance is normalized, but not overmedialized.

4. Tuberosity Fixation
The tuberosity is temporarily fixed with a Kirschner wire. Patellar tracking is viewed, and if it is acceptable, the tuberosity is fixed with interfragmentary screws (the screws are aimed medially, with care taken to avoid vascular injury).

Anteromedialization
1. Exposure
If the AMZ is an isolated procedure, begin the midline longitudinal incision midway between the patella and tuberosity and extend it distally 10 to 15 cm. Alternatively, the incision can course from the anterolateral portal to the same point on the tibial crest distally. Proximal extension may be performed to allow concomitant patellofemoral cartilage restoration. The patellar tendon is exposed subcutaneously. The lateral aspect of the patellar tendon is released, isolated, and protected. This lateral peripatellar tendon incision is extended proximally to the lateral release (noting the specific lateral release indications discussed earlier) and then distally along the anterior tibial crest to begin elevation of the anterior compartment musculature (Fig. 74-4). To allow anteriorization, a release is also performed immediately adjacent to the patellar tendon medially. The freed patellar tendon is protected with a retractor (Fig. 74-5). The anterior compartment musculature is subperiosteally dissected, and a retractor is positioned at the posterior extent of the lateral tibial wall to protect the posterior neurovascular structures (Fig. 74-6).

2. Planning of the Osteotomy
With use of a commercially available AMZ osteotomy system (Tracker by Mitek, Raynham, Mass), the osteotomy starting entrance position is planned by placing the cutting block jig medial to the patellar tendon attachment to the tibial tuberosity (Fig. 74-7). The planned osteotomy begins adjacent to the medial patellar tendon and courses laterally as it runs distally to allow the osteotomy to exit distally and laterally (a triangle shape). A drill guide—like arm is inserted into the cutting block. The tip of the slope selector arm predicts the lateral wall exit of the oblique osteotomy (Fig. 74-8). The tip (osteotomy exit) should be on the lateral wall of the tibia, always anterior to the
posterior wall. With the cutting block immediately adjacent to the patellar tendon attachment medially and the slope selector tip just anterior to the posterior wall, the slope is approximately 60 degrees (Fig. 74-3C, left). By moving the cutting block medially and the slope selector anteriorly, the slope can be decreased, for example, to 45 degrees. A smaller angle provides increased medialization relative to anteriorization. That is, the suggested anteriorization of 1.2 to 1.5 cm is “constant,” and thus with a steep slope (60 degrees), the medial displacement would be 0.6 to 0.75 cm; for a 45-degree slope, the same elevation would allow 1.2 to 1.5 cm of medialization.

3. Performance of the Osteotomy

With the desired slope selected, the cutting block is temporarily fixed to the tibia with pins through drill holes (Fig. 74-9). The oblique cut is made with an oscillating saw cooled with saline. The saw is directly observed as it exits on the lateral wall of the tibia anterior to the retractor (Fig. 74-10). The cutting block is removed. The oblique cut is
finished proximally and distally with use of the original bone cut as a captured saw guide (Fig. 74-11). To finish the proximal osteotomy, an osteotome connects the posterolateral wall saw exit site to the lateral aspect of the patellar tendon attachment to the tibial tuberosity (Fig. 74-12). Changing the angle of the osteotome, the last bone cut connects the previous cuts that have extended just proximal to the patellar tendon attachment to the tibial tuberosity medially and laterally. At this point, the tuberosity pedicle is free to rotate up the inclined slope.

4. Tuberosity Fixation
The completed oblique cut allows movement of the tuberosity pedicle up the inclined plane, affecting the desired anteromedialization. The tuberosity is temporarily fixed with a Kirschner wire, and the anteriorization and medialization are measured (Fig. 74-13). The tuberosity is fixed with interfemoral technique, with avoidance of vascular structures as discussed by Miller (Fig. 74-14).

Postoperative Considerations

Follow-up

- Standard knee management includes a protective brace locked at or near extension initially, compression, cryotherapy, elevation, and possible continuation of the femoral nerve block (Fig. 74-15). The limb is observed for compartment syndrome and any problems with skin healing.
- Sutures and staples are removed at 7 to 10 days.
- Radiographs are typically obtained perioperatively and then at 6 weeks postoperatively. For comparison of preoperative and postoperative radiographs, see Figure 74-16.

Rehabilitation

- The less extensive osteotomy of the TTM allows the patient to begin weight bearing with crutches as tolerated. AMZ requires limited weight bearing with two crutches for 6 weeks to minimize fracture. The initial protective brace may be discontinued when the patient is safe and has excellent quadriceps control.
- Early postoperative exercises serve to improve venous flow, to maintain quadriceps function, and to maintain

Figure 74-12 The two osteotomes represent the final proximal cuts. The more posterior osteotome courses from the proximal extent of the posterior oblique cut to the lateral attachment of the patellar tendon to the tuberosity. The second osteotome connects the lateral cut just made to the cut already present on the medial aspect of the patellar tendon attachment to the tuberosity. Note the retractor protecting the patellar tendon. Also note that the angles of the cuts are quite different.
Figure 74-13 After the tuberosity is repositioned up the slope of the osteotomy, it is fixed temporarily with a K-wire, and the anteriorization (A) and necklization (B) are checked.

Figure 74-14 The tibial tuberosity is fixed with two 4.5-mm interfragmentary screws in the new position.

Figure 74-15 Postoperative management with antithrombotic hose, a cryotherapy device, and a hinged brace locked in extension of 0 to 30 degrees. Note the two catheters proximally for the femoral and sciatic regional nerve blocks. The sciatic catheter is removed immediately after surgery; the femoral catheter may be used for added pain control.
patellar mobility. The patient is rapidly progressed to a comprehensive core proximal muscle strengthening program and range-of-motion exercises. Depth, grade, and region of chondral lesions and restoration will dictate the type and flexion angle of patellofemoral loading exercises.

- The AMZ is protected with a brace locked in full extension or 0 to 30 degrees for ambulation; the brace is removed for supine heel slides. The stationary bicycle is started early for range of motion.

**Complications**

Complications are similar to those of any open bone procedure of the knee. These include fracture, malunion, loss of fixation, nonunion, infection, thromboembolic phenomenon, compartment syndrome, sympathetically mediated pain, arthrofibrosis, patella infera, and long-term progression of patellofemoral chondrosis. Additionally, failure to address preoperative surgical indications may lead to postoperative complications.
PEARLS AND PITFALLS

**Pearls**
- The goal for all tuberosity surgeries is "normalization" of the tuberosity position, that is, the surgery in not just to medialize or to anteriorize.
- Although computed tomographic scans are not obtained routinely, most patients have undergone a magnetic resonance imaging evaluation, which is useful for defining the regions of any chondrosis. This will aid in the planning of tubercle surgery (e.g., AMZ to unload a distal lateral area of chondrosis).
- The magnetic resonance imaging evaluation may have been performed at another facility, but it is still possible for the radiologist to go back to the images and to measure the TT-TG distance and the Coten-Deshamps ratio.
- The mean TT-TG distance of asymptomatic patients is 13 mm.
- The TT-TG distance is abnormal above 20 mm.
- The steepest AMZ angle is 600 degrees. For the typical 15 mm of elevation, this results in medialization of approximately 8 mm, which would normalize the elevated TT-TG distances in the majority of patients.
- An elevated Coten-Deshamps ratio (patella alta) would suggest that a component of distalization be added to normalize the position of the tubial tuberosity.
- Always measure hip internal and external rotation in the prone position. If there is excessive internal hip rotation, this implicates an increase in femoral anteversion, which should then be evaluated with computed tomography (hip, knee, and ankle) that will also detect excessive tibial external rotation.
- Preoperative rehabilitation prepares the limb and patient for recovery.
- Rehabilitation must emphasize proximal and core musculature and not just local muscles.
- The combination of cartilage restoration with AMZ (when specific chondral lesions are noted) may allow improved outcomes compared with either procedure alone.

**Pitfalls**
- Be alert for pain that is disproportionate to the surgery. Early intervention (including sympathetic blocks) may avoid progression to classic complex regional pain syndrome.
- Tibial tuberosity overmedialization increases medial patellofemoral forces and may lead to patellofemoral chondrosis and arthritis.
- Medial patellofemoral forces also increase with tuberosity medialization, so be very careful in considering the procedure in a varus knee to avoid acceleration of medial compartment wear.
- Warn patients of hardware pain and the potential need for removal.
- AMZ significantly weakens the tibia until healing. Early weight bearing will lead to an increased tibial fracture rate.
- Whereas a "little" medialization may be beneficial, more is not better. The goal is to normalize the TT-TG distance.
- Tibial tuberosity surgery cannot substitute for pathology of the MPFL causing patellar dislocations.
- The lateral release with tibial tuberosity surgery is only to balance the soft tissue. Overzealous lateral release may cause both medial iatrogenic dislocations and paradoxically an increase in lateral pathology.
- Tibial tuberosity surgery is contraindicated when the apparent lateral position is from a combination of excessive femoral anteversion and tibial external rotation.
- In patients with extreme trochlear dysplasia, the "burnout" at the entrance to the trochlea will continue to interfere with tracking unless it is directly addressed.
- Too much anteriorization can cause problems with skin healing and may significantly rotate the patella, causing abnormal contact areas.
- AMZ outcomes are poor with proximal pole, pantellar chondrosis or if there is trochlear chondrosis.
- Patella infera is a complicated problem and should be treated with a continuum of care; tuberosity surgery must have a thorough, scientifically based role if it is contemplated in that situation.

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Results

Both short- and long-term case series for TTM and AMZ demonstrate high percentages of good and excellent results (Table 74-1). However, these are case series and need interpretation within the ranking of evidence-based medicine. In addition, these results need to be reviewed with biomechanical studies (i.e., Cohen and Kuroda) in mind.

Table 74-1 Results

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Surgery Type</th>
<th>Follow-up (average)</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beilemans et al (1997)</td>
<td>AMZ</td>
<td>32 months</td>
<td>Lysholm scores: preoperative, 62; postoperative, 92</td>
</tr>
<tr>
<td>Buuck and Fulkerson (2000)</td>
<td>AMZ</td>
<td>8.2 years</td>
<td>86% good and excellent</td>
</tr>
<tr>
<td>Cameron et al (1986)</td>
<td>AMZ</td>
<td>2 years</td>
<td>82% good and excellent</td>
</tr>
<tr>
<td>Carney et al (2005)</td>
<td>TTM</td>
<td>26 years</td>
<td>54% good and excellent</td>
</tr>
<tr>
<td>Fulkerson (1983)</td>
<td>AMZ</td>
<td>35 months</td>
<td>All patients received substantial relief of pain</td>
</tr>
<tr>
<td>Fulkerson et al (1990)</td>
<td>AMZ</td>
<td>74.2 months</td>
<td>89% good and excellent</td>
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<tr>
<td>Naranja et al (1996)</td>
<td>TTM+Ant</td>
<td>46.8 months</td>
<td>53% good and excellent</td>
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<td>Pidotta et al (1997)</td>
<td>AMZ</td>
<td></td>
<td>72% improvement</td>
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<td>Sakai et al (1996)</td>
<td>AMZ</td>
<td>5 years</td>
<td>20/21 satisfactory</td>
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AMZ, anteromedialization; Ant, anteriorization; TTM, tibial tuberosity medialization.
References