Surgical Technique for
Anteromedialization of the Tibial Tubercle with the
Tracker™ AMZ Guide System

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Many surgical procedures have been used to realign the knee extensor mechanism. Proximally, Insall realignment or variations with imbrication of the vastus medialis obliquis (VMO) and medial patellar retinaculum, combined with a lateral release, have been used extensively to improve patellar tracking.[1] Distal realignment, in which the tibial tubercle is typically moved medially to improve patellar alignment, is the other common approach to extensor mechanism realignment.

Some tibial tubercle procedures, such as the Hauser[2] technique, have moved the tibial tubercle posteriorly "down" the medial slope of the tibia as the tibial tubercle is moved medially. Unfortunately, this type of procedure can increase loads on an already compromised patella. Others, such as the Emslie-Trillat[3] procedure, use a flat osteotomy cut behind the tibial tubercle and subsequent straight medial tibial tubercle displacement to realign the extensor mechanism. The importance of preventing overload on the realigned patella cannot be overemphasized. The frequently noted "benign" or "normal" chondrosis (often found in even asymptomatic individuals along the medial facet of the patella) may not be benign if it is subjected to increased forces after a straight medialization procedure. Furthermore, increased force onto a medial facet lesion sustained at the time of a dislocation may contribute to further chondral deterioration or increased symptoms.

Bandi[4] and Maquet[5] described procedures to reduce contact stress on the patella by elevating the tibial tubercle anteriorly. This has been helpful to many patients with patellar arthrosis. The original procedure attempted to unload the patella in patients with arthrosis and was not specific for those with concomitant malalignment.

The concept of anteromedial tibial tubercle transfer, as described by Fulkerson[6], combines the benefit of extensor mechanism realignment with unloading of the patellofemoral articulation through tibial tubercle elevation. An oblique osteotomy posterior to the tibial tubercle permits tibial tubercle displacement along a smooth osteotomy plane in an anterior and medial direction. Thus, anteromedialization (AMZ) is a natural evolution from those earlier procedures. In addition to combining realignment with elevation, distant bone graft harvest is avoided. The complication rate with anterior medialization has been lower than with straight anteriorization and no

report of a skin slough or compartment syndrome has been found.

Following 13 patients more than 10 years after anteromedial tibial tubercle transfer, Buuck and Fulkerson reported that 12 out of 13 had good or excellent results.[7] The average modified Lysholm score was 83.5 out of 100. Ten of these patients improved or were the same as one year postoperatively. This shows properly performed anteromedial tibial tubercle transfer gives sustained benefit in carefully selected patients.

PREOPERATIVE EVALUATION

Preoperatively evaluate the patient with patellar pain in an organized, systematic manner. Include a detailed history and physical examination, paying particular attention to the entire kinetic chain, from hip to foot, with obvious emphasis on the patella. “Malalignment” is a general term and must be evaluated in each component of the chain in each axis plane—that is x, y and z. Standard patellofemoral views, such as the Merchant view, used with the clinical tracking assessment, are usually adequate. In complicated cases, CT or MRI patellar tracking studies may be of assistance.

With this preoperative information in mind, formulate an initial plan using the Fulkerson classification (Table 1). At the time of surgery, the correlation to the Fulkerson classification may be further modified after the lateral release. (For example, there is variation in the movement of the patella medially after isolated lateral release from none to a moderate amount.) In addition to classification of patellofemoral mechanics, make further modifications of the planned technique on the basis of not only the depth and grade of the chondrosis, but also on the location of the chondrosis as recently described by Fulkerson et. al (Table 2). As well as potentially decreasing and medializing loads, it is important to remember that loads after AMZ are also transferred to more proximal areas of the patella earlier during range of motion.

Patients with diffuse patellar articular degeneration, proximal crush injury or nonspecific anterior knee pain are generally not candidates for this procedure. Patients with predominant sulcus chondrosis should be approached cautiously.

PROCEDURE

After arthroscopic evaluation and treatment, perform the lateral release and reassess tracking. Make a skin incision from the mid-patella level through the anterolateral portal in an oblique, slightly medial manner, ending about 5 to 10cm distal to the tibial tubercle (Figure 1). Divide the subcutaneous tissues in line with the skin and obtain hemostasis.

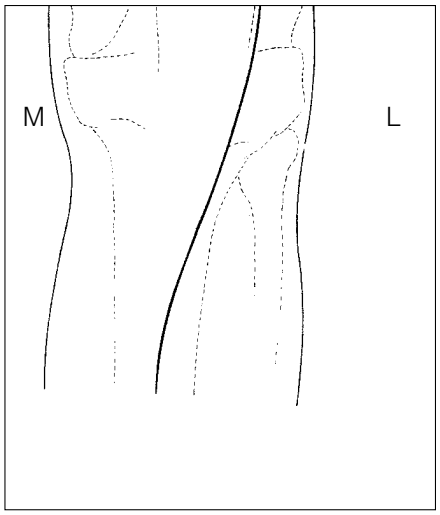
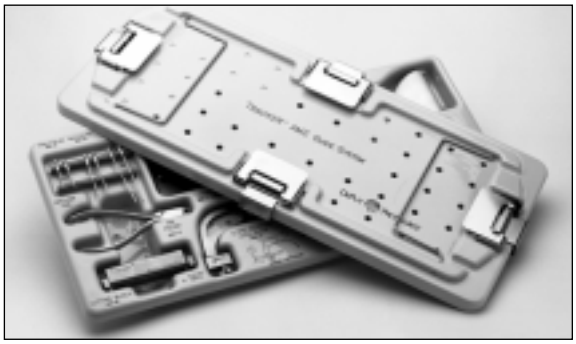


Figure 1: *The skin incision begins near the anterolateral portal and courses slightly medially to end distal to the tibial tubercle.*

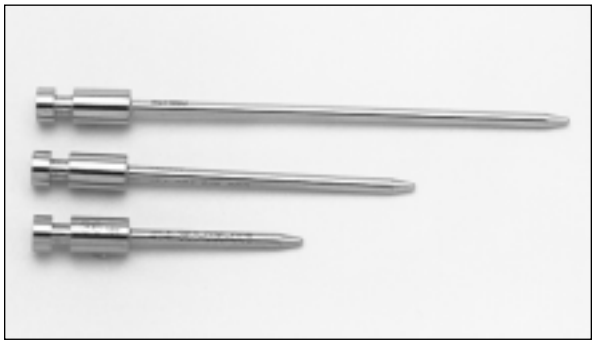
Continue the lateral release from its distal extent along the lateral aspect of the patellar tendon. Inspect the patella and trochlea to correlate the open and arthroscopic findings. This exposure allows fixation of chondral or osteochondral fragments or additional debridement.

Continue this lateral release extension along the lateral aspect of the tibial tubercle at the border of the anterior compartment, which is now bluntly elevated in a subperiosteal manner. Place the custom anterior compartment muscle retractor (Cat. No. 219454) subperiosteally with blunt ends directly adjacent to the posterior tibia,

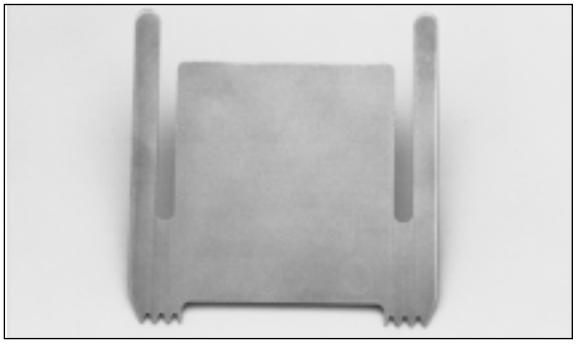
Tracker™ AMZ Guide System



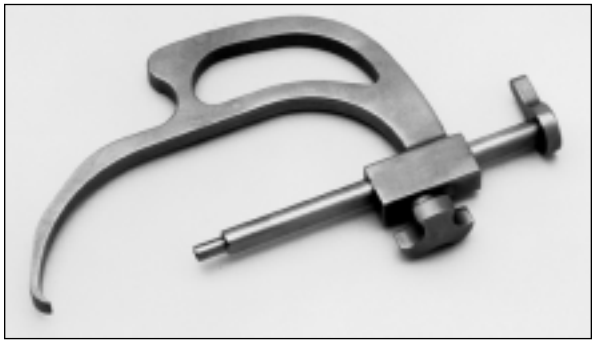
Module



Anchor Pins



Positioning Card



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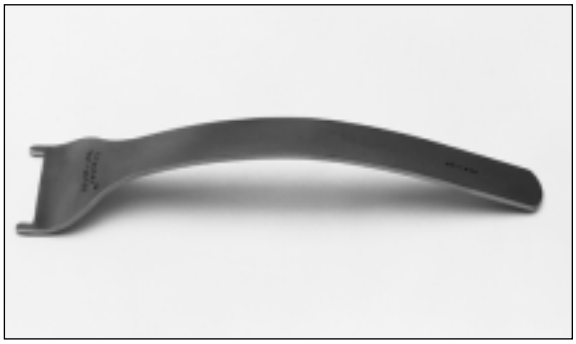
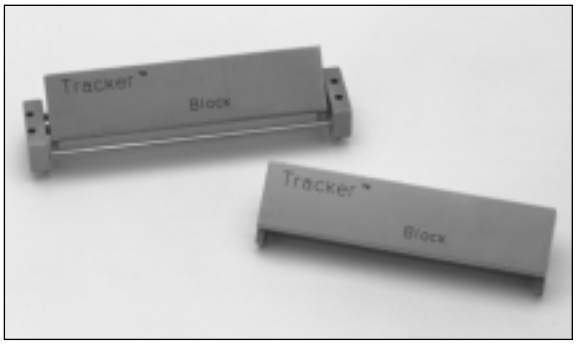
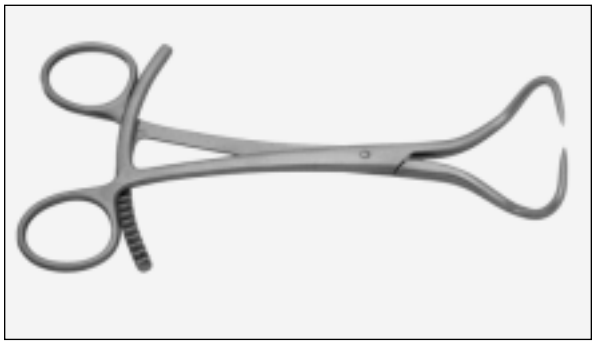


Retractor

Anchor Pin Puller



Cutting Block



Bone Clamp

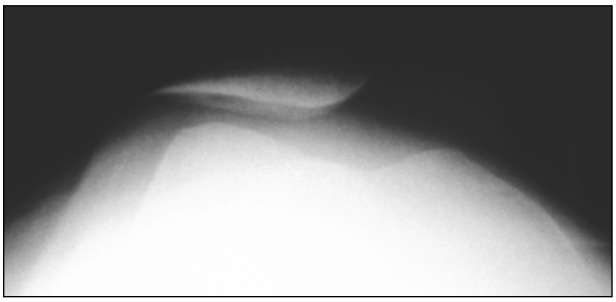
Case Study One

A 41-year-old female, C.M., had ten years of patellofemoral pain, with the majority of her pain in the left knee. She had a history of right and left patellar dislocations, and then subsequent subluxation with no further dislocations. Five to ten years pre-op, she had increased effusions proportional to activity, along with grinding, catching, giving way and extreme pain while climbing stairs. She failed to respond to conservative treatment.

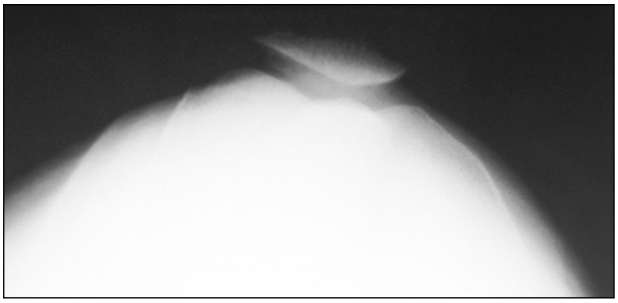
Weightbearing AP and flex knee PA radiographs revealed maintenance of tibiofemoral joint space, and the Merchant view demonstrated moderately shallow morpholgy with subluxation.

She had full range of motion, with no increased laxity or tibiofemoral pain. Her maximum pain was at the lateral facet, which was greater than direct patellofemoral pain. As suspected preoperatively, there was PF chondrosis (medial patellar facet and central sulcus), thus AMZ was selected rather than straight medialization.

Post-op radiographs revealed the desired elevation. The Merchant view demonstrated a centralized patella. Full pain relief occurred six months post-op.



Preoperative Merchant View —C.M.

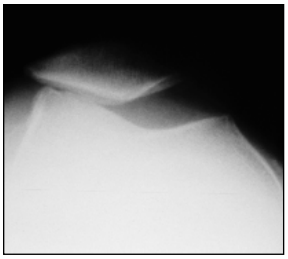


Postoperative Merchant View —C.M.

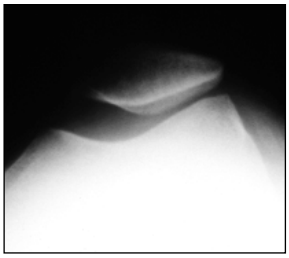
Case Study Two

C.H. is a 47-year-old female who had progressive patellofemoral pain for 10 years. Both patellofemoral joints had chronic patellar subluxation with degenerative changes and clinical lateral compression syndrome. She failed to respond to conservative management. The less-involved knee was treated first with AMZ and debridement. At four weeks post-op, C.H. had full motion, minimal discomfort and good quad function. At that point, the contralateral knee underwent AMZ and debridement. Both surgeries were performed on an outpatient basis under local anesthetic. C.H.'s postoperative course has been uncomplicated. She is pain-free on the less arthritic knee and has activity-related aching on the more arthritic knee.

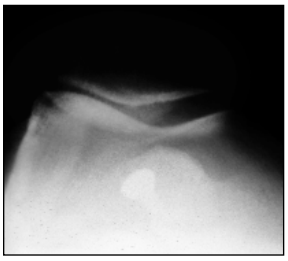
The postoperative Merchant views illustrate that when adequate lateral patellofemoral articular surface remains after anteromedialization, that surface will support the lateral aspect and the patella will appear centralized. However, a similar AMZ performed on a patient with exposed bone on the lateral trochlea and patella will not have lateral cartilage support; therefore, even though the patella is dynamically centralized and load-bearing is more medial, the lack of chondral support at the lateral aspect of the joint results in the appearance of an under-corrected subluxation/tilt. Such is the case in this patient. The surgery was performed correctly, the patient is happy, but the surgeon would like the postoperative x-rays to "look better".



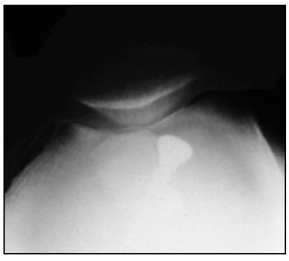
Left Preoperative Merchant View —C.M.



Right Preoperative Merchant View —C.M.



Left Postoperative Merchant View —C.M.



Right Postoperative Merchant View —C.M.

Classification of Patellofemoral Pain

Outerbridge Classification

Grade 1 Articular cartilage softening only
Grade 2 Articular cartilage fibrillation <0.5 inch in diameter
Grade 3 Articular cartilage fibrillation >0.5 inch in diameter
Grade 4 Erosion of articular cartilage with exposed bone

Source: Outerbridge, R.E.: The Etiology of Chondromalacia Patallae. Journal of Bone and Joint Surgery; 43B: 752m, 1961.

Modified Version (Dimensions Separate)

1. Softening
2. Fibrillation fissures partial (<50% thickness)
3. Fibrillation fissures deep partial (>50% thickness)
4. Bone exposed

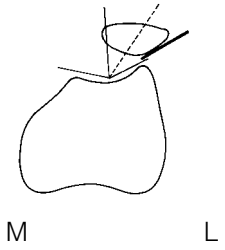
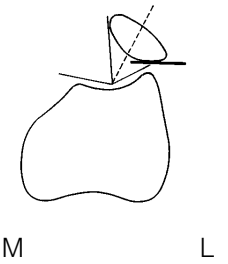
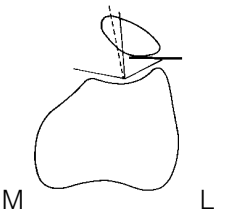
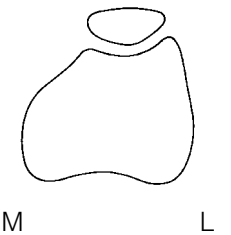
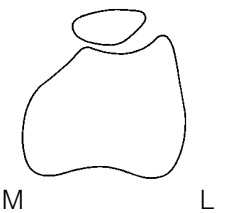
Fulkerson Classification I-V*	Patellar Alignment**	Treatment Options	Prognosis
Type I Subluxation **A** Includes subluxation with no articular lesions **B** Subluxation with minimal chondromalacia (grades I and II) **C** Subluxation with osteoarthritis grades III and IV)		**A** Straight Medialization **B** Shallow Slope AMZ **C** Moderate Slope AMZ	Excellent Excellent Good
Type II Subluxation with Tilt **A** Subluxation with tilt and no articular changes **B** Subluxation with tilt and minimal chondromalacia (grades I and II) **C** Subluxation with tilt and osteoarthritis (grades III and IV)		**A** Straight Medialization **B** Shallow Slope AMZ **C** Moderate Slope AMZ	Excellent Excellent Good
Type III Tilt **A** Patellar tilt with no articular lesions **B** Tilt with chondromalacia (grades I and II) **C** Tilt with osteoarthritis (grades III and IV)		**A** Physical Therapy, Rare LR **B** Steep Slope **C** Steep Slope/Possible Offset Grafting if lesion(s) is medial	Excellent Excellent Good
Type IV No Malalignment **A** No malalignment, no chondromalacia **B** No malalignment, chondromalacia is evident (grades I and II) **C** No malalignment, osteoarthritis is present (grades III and IV)		**A** Consider Retinacular or Referred Pain **B** Conservative Management **C** AMZ with local offset graft (Resultant straight anteriorization provided there is intact proximal cartilage)	Variable Guarded Good
Type V Medial Facet Chondrosis **Post Realignment (i.e. Hauser)**		Anterolateralization	Variable

Table 1

* *Sports Medicine and Arthroscopy Review, Vol. 2, No. 3, 1994*
** *OrthoClinic, NA, 17:235-248, 1986*

Chondrosis Site Classification

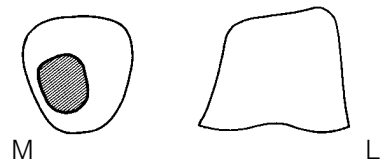
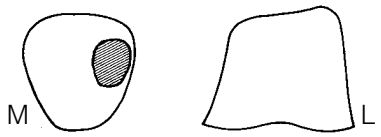
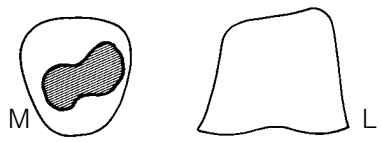
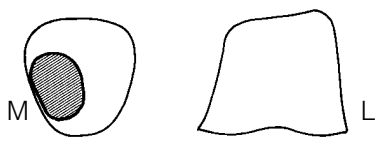
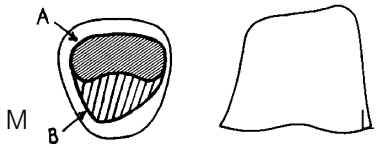
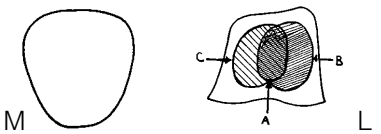
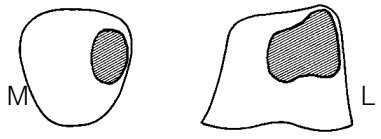
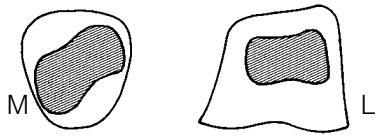
Type of Site Chondrosis	Comments	Morphology	Effect on Prognosis
I. Distal Medial/Central Facet Patella	**Previously thought to be a normal variant—may not always be benign**		**Possible increased pain after straight medialization**
IIA. Lateral Facet Patella	**Associated with "Excessive Lateral Pressure Syndrome."**		**Classic for AMZ**
IIB. Dumbbell (Type I and Type IIA Chondrosis Pattern)			**Good**
III. Post Dislocation Chondrosis Medial Facet	**Variable depth and size**		**Guarded**
IV. Proximal Pole Patella **A Proximal pole alone** **B Proximal and distal**	**Often secondary to dashboard injury or direct impact (falls)**		**Poor**
V. Isolated Sulcus **A Central** **B Central Lateral** **C Central Medial**	**Often observed by plica or synovium unless visualization optimized**		**Variable as related to area, depth, and possibly, patellar position**
VI. Central/Lateral Sulcus Lateral Patella			**Less than patella alone**
VII. Extensive Sulcus/ Extensive Patella			**Poor**
VIII. Medial Post-Hauser			**Good**

Table I

* *Sports Medicine and Arthroscopy Review, Vol. 2, No. 3, 1994*
** *OrthoClinic, NA, 17:235-248, 1986*

SPECIAL PRECAUTIONS

1. Patient Expectations—As with many aspects of life, expectations play a very important role in satisfaction. Even after a technically correct procedure, some degree of discomfort is not uncommon, since the degenerative changes remain. Take extra time to explain that the knee joint will have the same "worn out" parts after surgery. The patella will be in a new position in an attempt to decrease patellofemoral force, which usually decreases pain, but the patellofemoral joint will still have degenerative changes. Crepitus and "popping" may remain postoperatively, so make sure to alert patients during preoperative counseling. A realistic goal is improved comfort and endurance, not total pain relief. High level sports may not be possible.

2. Quad Strength—Continue emphasis on the patient's responsibility in rehabilitation. Communicate that optimal comfort will not be achieved until full quadriceps (and entire extremity) strength has been restored. In the early post-op period, do not hesitate to use physical therapy, functional electrical stimulation or biofeedback to "jump-start" quadricep strengthening and function.

3. Psychologic Profile—As in cosmetic surgery cases, be certain the cause of knee pain is the knee and not a focus for other problems.

4. Smokers—As with other procedures which increase tension on the skin, the vascular supply may become borderline. The plastic surgery literature demonstrates that nicotine further compromises blood flow. Thus, smokers should quit several weeks before surgery and abstain postoperatively.

5. RSD—Sympathetic pain may be observed post-op. Atypical pain may be evaluated by differential blockade and treated appropriately.

6. Secondary Gain—Secondary factors must be separated from organic factors. All patellofemoral surgery must be approached with caution when there is potential for secondary gain, and when patient motivation for rehabilitation is low.

7. "Dashboard" Injuries—As the proximal pole is often involved, the prognosis after any surgical procedure is highly guarded in these patients.

SPECIAL PROCEDURES

1. Straight Anteriorization—In patients with central tracking and patellofemoral arthritis, straight anteriorization can be achieved using the Tracker AMZ Guide System. After all bony cuts are made, the tubercle fragment is first temporarily anteromedialized. It is then moved laterally to a central position to effect a "straight anteriorization" by a locally obtained offset graft as previously described by Fulkerson.

2. Anterolateralization—Patients who are experiencing degenerative change and pain after a prior medialization, such as a prior Hauser procedure, may be treated by reversing the posteromedialization. The medial facet can be unloaded and the tibial tubercle elevated to further unload the patella through anterolateralization. The placement of the Tracker Guide System is such that the slope permits anterolateral shift of the tibial tubercle.

3. Local Anesthetic Option—Through meticulous use of subperiosteal local anesthetic, in addition to standard soft tissue anesthetic, the majority of the procedure—including bony cuts—may be performed under local anesthetic with supplemental I.V. sedation.

Optionally, this free fragment may be hand held for assessing patellar tracking and for drilling. Place the knee through its range of motion to assess tracking, and adjust the tubercle to achieve desired elevation and central tracking.

If tracking remains too lateral, the tibial tubercle can be further medialized at this point. If the tracking is too medial but has the desired amount of elevation, a local offset bone graft may be used. This was previously described by Fulkerson as a way to maintain anteriorization while decreasing or fully neutralizing the amount of medialization. Move the tibial tubercle proximally or distally for concomitant problems with baja or alta, respectively.

Use two 4.5mm ACE Medical Company cortical bone screws of the appropriate length to purchase the posterior cortex using an interfragmentary technique. With direct, precise measurement, and countersinking as appropriate, the proximal screw is secured first.

The bone clamp may then be removed to allow insertion of the drill sleeve at the distal hole and completion of interfragmentary fixation of the tubercle. At least one of the screws should be

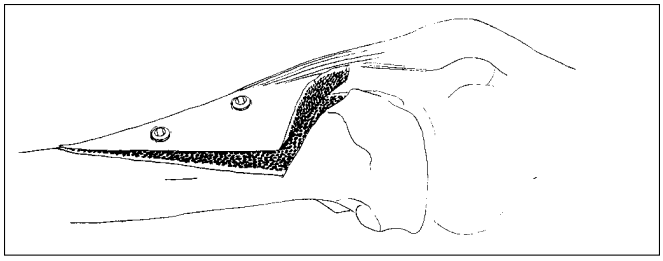


Figure 12: *With the proximal screw in place, the bone clamp is removed from the distal hole to completely secure the bone fragment.*

perpendicular to the osteotomy (Figure 12).

There is usually a sharp edge of medial bone at the proximal extent of the transferred tubercle. After measuring the elevation, cautiously and conservatively round this sharp region with a rongeur so it does not impinge on the patellar tendon through range of motion. (Note: this may diminish the measured radiographic elevation appearance of the tibial tubercle elevation postoperatively.)

The procedure may be performed with or without a tourniquet to this point. If the procedure has been performed with a tourniquet, deflate the tourniquet at this time and pay close attention to achieving hemostasis, especially in the region of the fat pad and the geniculate branches.

Postoperatively, place the patient in a standard compressive knee dressing using a compression ice wrap. Use a drain for the immediate postoperative period.

POSTOPERATIVE MANAGEMENT

Control swelling by continuously cooling and elevating the limb. Begin immediate quadricep-setting exercises to maintain quadricep control. Encourage a normal gait with foot flat/minimal weightbearing for the first six weeks using two crutches.[8]

Continue to encourage the patient to maintain quadricep function and strength, then proceed with range of motion and further strengthening by using an exercise bicycle on low resistance.

Counsel the family to help avoid potential falls by freeing the living area of area rugs, unruly pets underfoot, etc. At six weeks, check radiographs of the osteotomy. As determined by the radiographic and clinical evaluation, progressively increase weightbearing as tolerated, so the patient is full weightbearing and off crutches by eight weeks. Since the osteotomy will serve as a stress riser to the tibia, give specific instructions to the patient about avoiding twisting or turning of the extremity to prevent fractures.The patient should progressively advance activities of daily living, avoiding stairs until optimal quadricep strength is reestablished.

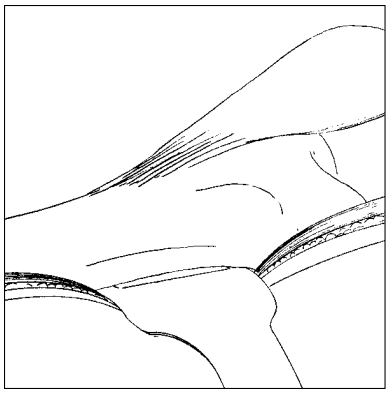


Figure 2: *Custom retractor positioned subperiostally below the tibia.*

protecting the neurovascular structures, (anterior tibial artery and deep peroneal nerves are immediately behind the posterolateral tibia) (Figure 2).

Expose the entire tibial tubercle by gently retracting the skin medially while minimizing dissection of soft tissue attachments. Incise the retinaculum longitudinally at the medial aspect of the patellar tendon along its distal three centimeters. This allows full medial and lateral visualization of the patellar tendon before the osteotomy as it attaches to the tibial tubercle and unconstrained elevation after the osteotomy.

Using the cutting block position card (Cat. No. 219458), select the site of the anteromedial periosteal cut along the medial aspect of the tibial tubercle. The position of this cut depends upon the desired slope angle, as referenced in the Fulkerson classification chart (Table 1). For example, the steeper the desired slope, the closer this anterior cut will be to the patellar tendon. On the other hand, a gentle slope will place this cut more medially. The extreme example would be the horizontal cut of a straight medialization.

The slope selector arm (Cat. No .219455) fits over either end of the cutting block position card to estimate where a sloped osteotomy would exit posterolaterally (Figure 3).

Use a marking pen to trace the planned cut. The obliquity of the cut should be determined such that the proximal posterolateral corner of the osteotomy will end at least 5-10mm anterior to the posterolateral tibial cortex. The cutting block, either with or without the pivot base, (Cat. Nos. 219453 or 219452, respectively), is then slipped over the cutting block position card. Once comfortable with the procedure, you may choose to discontinue use of the positioning card.

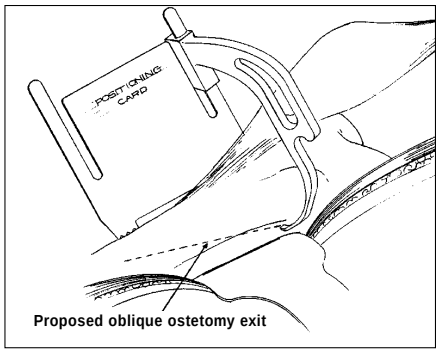


Figure 3: *Positioning card with slope selector arm attached.*

When using the cutting block with the pivot base, attach the ends of the base to the tibia by using a 2mm drill (Cat. No. 219460) and unicortical short anchor pins (Cat. No. 219465) (Figure 4). Unicortical predrilling prior to pin insertion is required. Proximally, one or two pins may be inserted for attachment, while only the medial pin will be used distally because of block overhang due to the distal tibia's apex shape and oblique course of the planned cut.

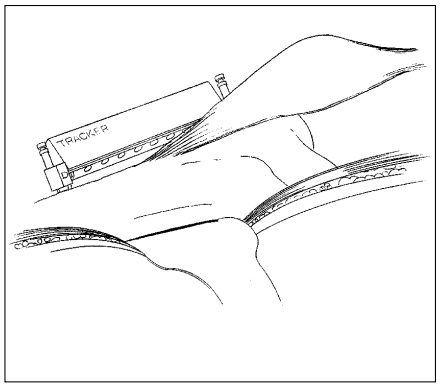


Figure 4: *Appropriate length unicortical anchor pins securing pivot base to tibia.*

With the pivot base secured, pivot the cutting block guide on the base to the desired slope using the slope selector arm. Remember to taper the osteotomy anteriorly as the osteotomy plane is continued distally. Alternatively, the cutting block alone may also be held in position freehand (Figure 5). The choice of Tracker™ System cutting blocks is based on surgeon preference

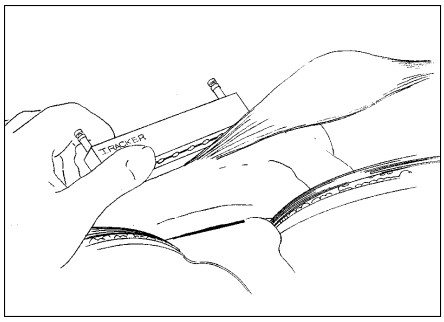


Figure 5: *Cutting block without pivot base held in position freehand and then fixed aboe with unicortical and below with biocortical 2.0mm anchor pins.*

and should reflect the surgeon's experience level and familiarity with the procedure.

Attach the slope selector arm assembly (Cat. No. 219455) to the cutting block by inserting the slope selector cannula into the desired hole on the drill guide. The slope selector arm will be adjacent to the tibia's exposed lateral wall, which is the exit site of the osteotomy (Figure 6). This predetermines the eventual, final posterior cut exit level and the resulting slope. (**Special Note:** Unlike the Restore™ ACL Tibial Guide, the slope selector is not designed to be rigidly secured to the tibia. The Tracker Slope Selector must be hand held in the desired exit position with gentle pressure to maintain position when drilling.)

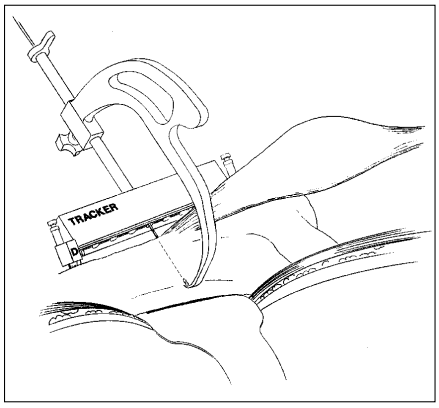


Figure 6: *Slope selector attached to cutting block, guiding the 3.2 mm drill pin posteriorly to the exit site on the tibia.*

Orient the osteotomy plane so that no drill bit, osteotome or saw breaks through the posterior tibia. This can be prevented by carefully planning the osteotomy plane with the slope selector arm. The system allows any of the cutting block guide holes to be used, based on surgeon preference.

Use a 3.2mm drill bit (Cat. No. 219461) to both temporarily fix the block and to confirm an osteotomy exit site as the drill bit tip exits (under direct observation) at the slope selector tip.

The drill is removed from the drill bit (which remains to hold the block in place (Figure 7). The 2.0mm drill is then used to make holes in the tubercle through the extreme proximal and distal holes of the cutting block (unicortical proximally and bi-cortical distally). Anchor pins are inserted in these holes to hold the block securely. As familiarity with the system increases, the 3.2mm drill step may be skipped.

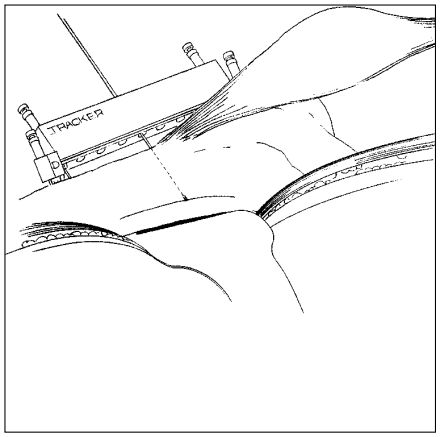


Figure 7: *A 3.2mm drill bit in the middle drill hole secures the cutting block before distal and proximal anchor pins are placed*

(**Note:** To further minimize the potential of deflection, only use new, sharp drill bits and apply low, even pressure while drilling).

When comfortable with the accuracy of the planned saw cut (double check with the slope selector), use an oscillating saw through the cutting block saw guide. Begin the cut distally

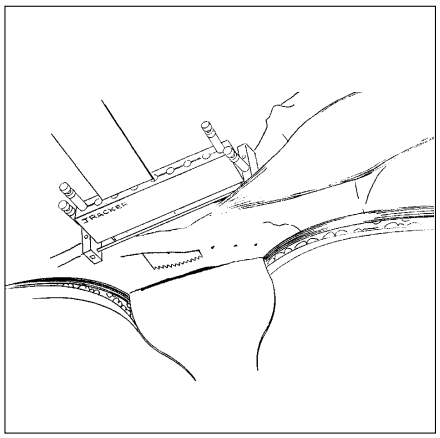


Figure 8: *If an osteotome will be used, make multiple drill holes with the cutting block firmly in place. No holes are needed if the oblique cut will be made with a saw blade. Note the anterior taper of the osteotomy distally.*

so the saw blade is easy to see as it exits the tibia along the slope (Figure 8). Proceed with caution proximally where it is more difficult to see the saw blade. Note that posterior structures are protected by the retractor as long as the retractor is in proper position, but saw **only** when full visualization is maintained.

The original technique described by Fulkerson is to make multiple 4.5mm drill holes through an aiming block and then allow an osteotome or saw blade and "connect the dots". With a properly placed and secured cutting block, this generally is not necessary. Dr. Fulkerson now typically uses a saw through the block.

Remove the cutting block from the tibia by pulling the anchor pins using the Anchor Pin Puller (Cat. No. 219456) (Figure 9).

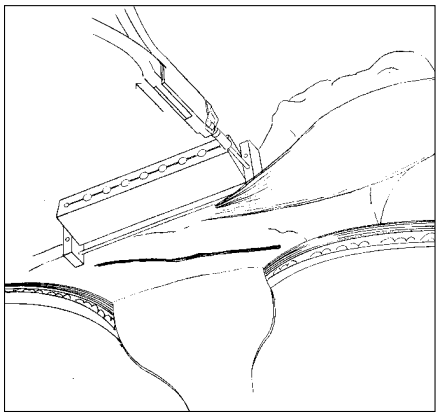


Figure 9: *The Anchor Pin Puller captures the head of the anchor pin to remove the cutting block.*

To free the tibial tubercle, connect the proximal posterior cut with the proximal anterior cut by using two linking cuts at slightly different angles. Angle the first cut from the proximal posterolateral aspect of the osteotomy and gently continue proximally and anteriorly. End the cut just proximal to the lateral aspect of the patellar tendon insertion. To allow rotation, make a gentle, proximally angled second cut directed from this lateral site to the osteotomy site proximal and medial to the patellar tendon insertion (Figure 10). The cuts can be made with any appropriately sized osteotome or sagittal saw, but great care must be taken to avoid injuring the patellar tendon and its insertion.

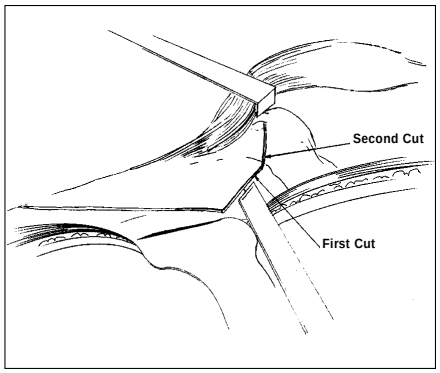


Figure 10: *The Proximal posterior cut is connected to the proximal anterior cut using two linking cuts at slightly different angles proximal (above) to the patellar tendon insertion.*

As is common in total joint reconstruction, use the previous saw cut track as a "captured guide" to finish the primary osteotomy plane cut proximally and distally. Osteoclasis can then easily be performed through a very thin layer of cortex distally. A smooth anterior taper of the osteotomy distally may decrease the stress riser effect at the distal aspect of the osteotomy.

Next, loosen the tibial tubercle fragment with an osteotome and rotate anteromedially. To temporarily secure this fragment, drill a distal 4.5mm hole in the tubercle fragment only, through which the Tracker Bone Clamp (Cat. No. 219457) will firmly hold it. With hard tibial bone, the other site of the clamp fixation may require superficial drilling to establish a foothold. Use an anchor pin proximally, which is placed lateral and adjacent to the free tibial tubercle (without exiting the posterior cortex) to further stabilize the fragment (Figure 11). This is superficial, temporary fixation only.

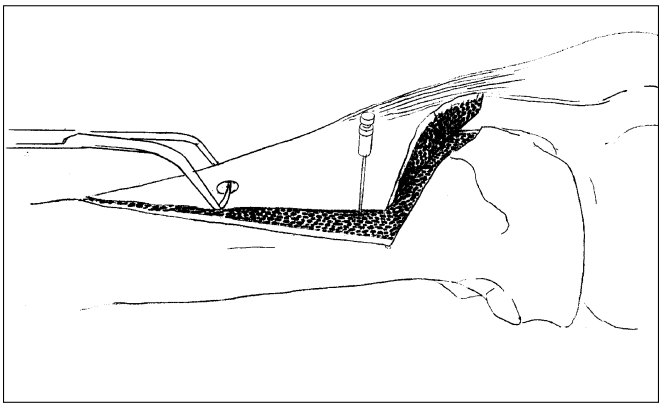


Figure 11: *The bone clamp secures the fragment distally, while an anchor pin stabilizes the fragment proximally. First approximation, 12-18mm desired elevation.*

Contraindications: None known

Caution: Federal law (USA) restricts this device to sale by or on the order of a physician.

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