A New Bone Anchor for Re-Attachment of Soft Tissue and Management of Fractures and Dislocations

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The attachment of soft tissue to bone is a problem in orthopedic surgery. Over the last one hundred years several methods have been used.[1] The earliest method involved drilling a hole in the bone, pulling the tendon through the hole and sewing the tendon onto itself. While this worked on tendon transfers, it did not work particularly well around the knee, shoulder and the ankle where there are large areas of cancellous bone and the tissue to be reattached is ligamentous and is less well-defined than a tendon.[2,3]

The second method was to split the periosteum, prepare a trough in the bone, and sew the tendon or the soft tissue directly into the periosteum. This method requires long immobilization of the joint, and while it does work, the immobilization often leads to arthrofibrosis. Staples, nails, tacks, and other devices have been used to attach soft tissue with various degrees of success.

Regardless of the attachment method, the tissue often pulled out of the bone, especially in the area of cancellous bone. Newer methods of attaching sutures to bone, which is then sutured into the tendon, are now popular. These devices are fixated into cancellous bone by way of hooks or threaded rods and work well in cortical bone. They have failed, however, around the shoulder and are not recommended for ligamentous repair.[4]

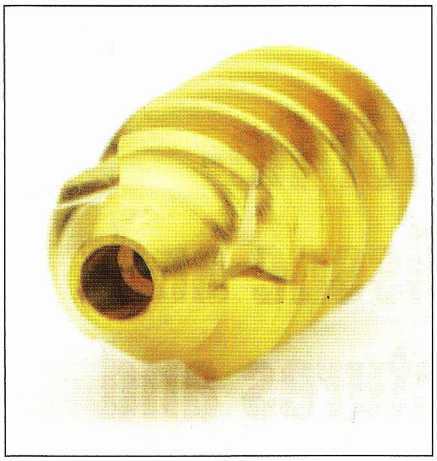

Figure 1. The AME Ogden Anchor. The AME Ogden Anchor is a headless, corticocancellous screw which has been barrel-drilled for the suture (#2). The screw is self-tapping with a cannulated recess for the knot to prevent binding. The screw is fully threaded and the pitch of the threads is coarse and deep to provide better holding power in cancellous and poor quality bone.

The most frequent repair of the rotator cuff is performed by making a trough into the greater tuberosity, the repaired cuff is then pulled into this trough by suturing through the bone and then tying the suture over the bony bridge. While this has been successful, it is often technically difficult to perform due to the osteoporosis and softness of the bone on the superior part of the humerus.[5,6]

In order to attach the suture to the bone in a more secure fashion, the AME Ogden Anchor was developed. The AME Ogden Anchor, was made as a headless, barrel-drilled screw with a larger recess at the end of the device so that a suture could pass through the screw (Figure 1).[7] An overhand knot, joining the ends of the suture, would then be contained in this recess and would not pull through the barrel-drilled screw. It was found that the pull-out strength of the screw in bone is dependent upon the pitch and relative size of the screw. Studies have shown that the ideal size of a bone screw requires at least three threads to be within the cancellous bone and the screw should have a diameter of at least 4.5 mm.[8,9,10] This was the basis of the design criteria for the anchor for use in the shoulder.

The actual preparation of the anchor for surgical application is quite simple and requires few instruments. Suture (#2) should be passed through the loop of the suture passer. The free ends of the suture should be aligned and tied in an overhand knot (Figure 2a). With the anchor on the screwdriver, the shaft of the suture passer should be inserted through the anchor and out the screwdriver base (Figure 2b). Then pull firmly on the suture to set the knot

LOADING THE SUTURE

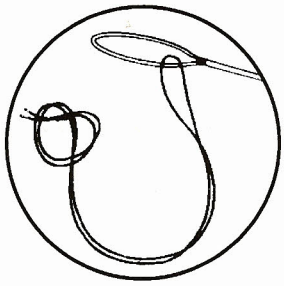

Figure 2a. Use #2 (5.0 metric) suture. Pass the suture through the loop of the suture passer. Align the free ends of the suture and tie an overhand knot.

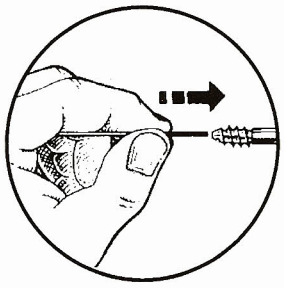

Figure 2b. Place the anchor onto the screwdriver. Holding the anchor in place with one hand, insert the shaft of the suture passer into the tip of the anchor, through the shaft of the screwdriver and out the screwdriver base.

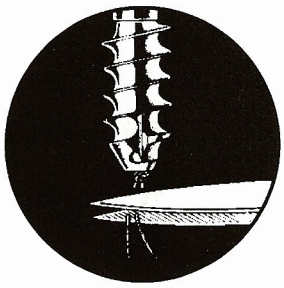

Figure 2c. Pull firmly on the suture to set the knot into the tip of the anchor.

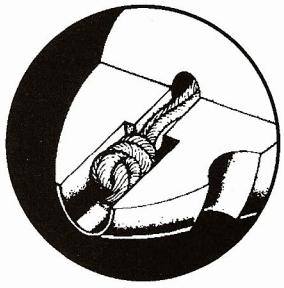

Figure 2d. Trim the excess suture (leaving 1.0 mm. at the tip of the anchor where the knot lies, taking care not to compromise the integrity of the suture knot. The suture passer can be removed and discarded by cutting the suture near the loop protruding from the inserted handle.

PREPARING THE PILOT HOLE

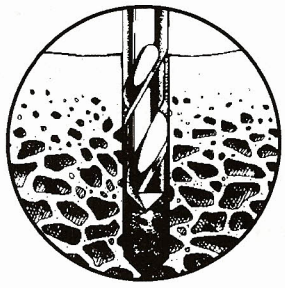

Figure 2e. Use the awl to open the cortex and prevent the drill bit from slipping. Using a 4.5 mm drill bit, prepare the pilot hole by drilling perpendicular to the bony surface.

DRIVING THE ANCHOR

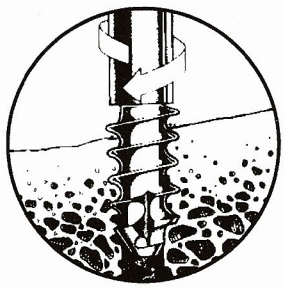

Figure 2f. Place the self-tapping anchor/anchor driver assembly at the pilot hole. Turn the anchor driver clockwise until the anchor is seated 1.5-2.0 mm below the surface of the bone.

Figure 2g. Remove the screwdriver from the anchor, leaving the freed ends of the suture. Use the needle of choice to reapproximate soft tissue to bone. If more than one anchor is needed, the procedure is repeated. Placement of a second anchor must be at least 10 mm away (center to center)- from the first one.

Figure 2. Preparation of Anchor for Surgical Application.

into the tip of the anchor. Trim the suture at the end of the knot leaving one mm (Figure 2c). The suture should be cut to free the suture passer, leaving two strands of suture for soft tissue attachment (Figure 2d).

The anchor is ready for insertion. The site for insertion needs to be prepared in the following manner: First, an awl may be used to open the cortex and prevent the drill bit from slipping. A 4.5 mm drill bit should be used to drill the hole perpendicular to the bony surface (Figure 2e). By placing the self-tapping anchor/anchor driver assembly at the pilot hole, the anchor driver should be turned clockwise (Figure 2f) until the anchor is seated 1.5-2.0 mm below the surface of the bone (Figure 2g). Remove the screwdriver from the anchor and use the free ends of the suture for tissue attachment. Use the needle of your choice. If more than one anchor is needed, the procedure is repeated. Placement of a second anchor must be at least 10 mm away (center to center) from the first one.

Currently, only one size of the anchor is available, but smaller sizes of the anchor are under development and should be released soon. The early clinical trials showed excellent attachment to bone and was simple to use. Comparative pullout studies with other suture attachment devices show that the AME Ogden Anchor is far superior in pullout strength. This study was performed by placing the screw in cadaveric tibial cancellous bone with the pullout studies performed using direct strain gauges to assess the gripping power of the screw to the bone. It was found that the weakest link of the AME Ogden Anchor was the suture itself (suture breakage). When compared to the other devices on the market for pullout strength from cancellous bone, the AME Ogden Anchor was found to be exponentially stronger.[11] Clinically, when compared with the other devices on the market, the anchor was found to be much more suited to the cancellous bone about the shoulder for which it was used primarily as a method of attaching the soft tissue to the shoulder. Though the device has been marketed for repair of the rotator cuff, it is useful wherever there is a need to attach soft tissue to bone.

Figure 4. Alternate Application and Preparation of the Anchor in Rotator Cuff Repair.

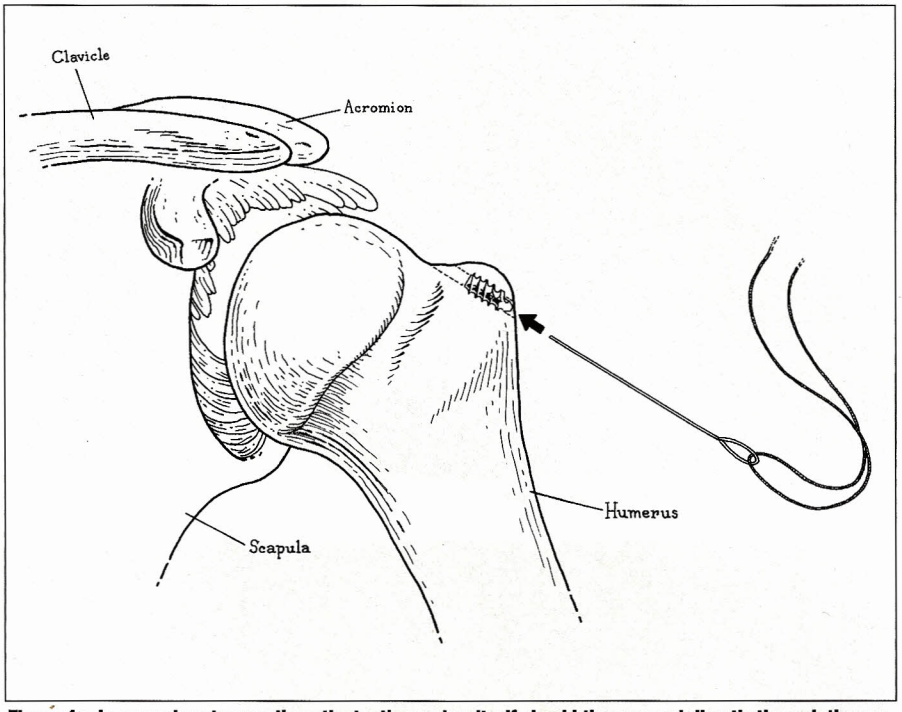

Figure 4a. In severely osteoporotic patients, the anchor itself should then passed directly through the cortical bone in the more lateral aspect of the humeral shaft. The angle of this is essentially in line with the pull of the rotator cuff. The threading of the anchor then is carried out by passing the suture threaded though the loop of the suture passer through from the end of the anchor.

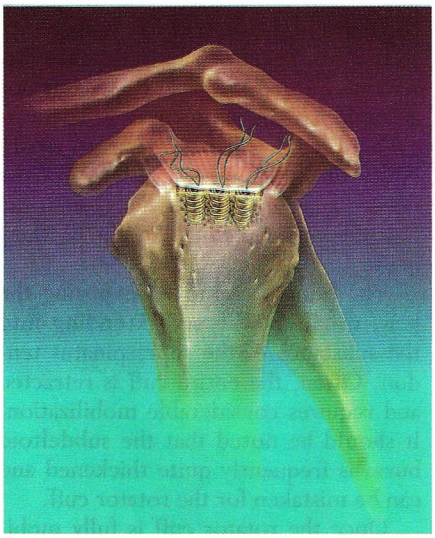

Figure 3. Application of Anchor in Rotator Cuff Repair. Three anchors placed in trough of humeral head for rotator cuff attachment. The top of the anchor is countersunk 2 mm so that the cuff attaches to bone.

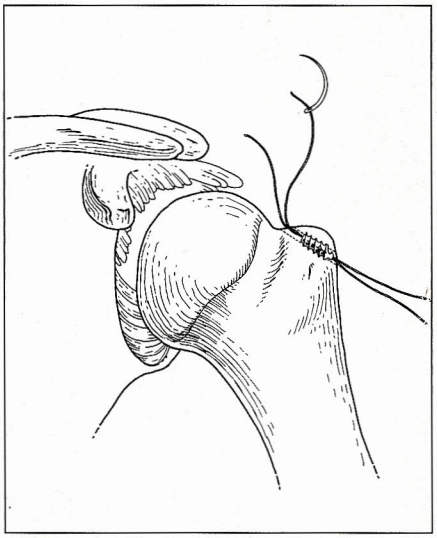

Figure 4b. The suture is cut is then cut and the two pieces of suture may be sewn into the cuff. The cuff then pulled down into its trough.

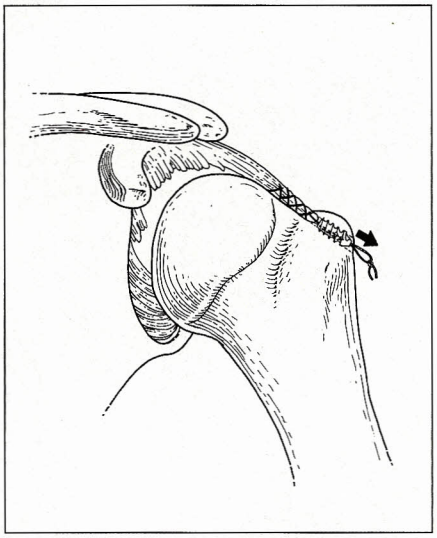

Figure 4c. The suture is then tied directly over the anchor itself so that the knot falls into the cannulated recess of the end of the anchor.

Figure 5. Radiographs of Rotator Cuff Repairs.

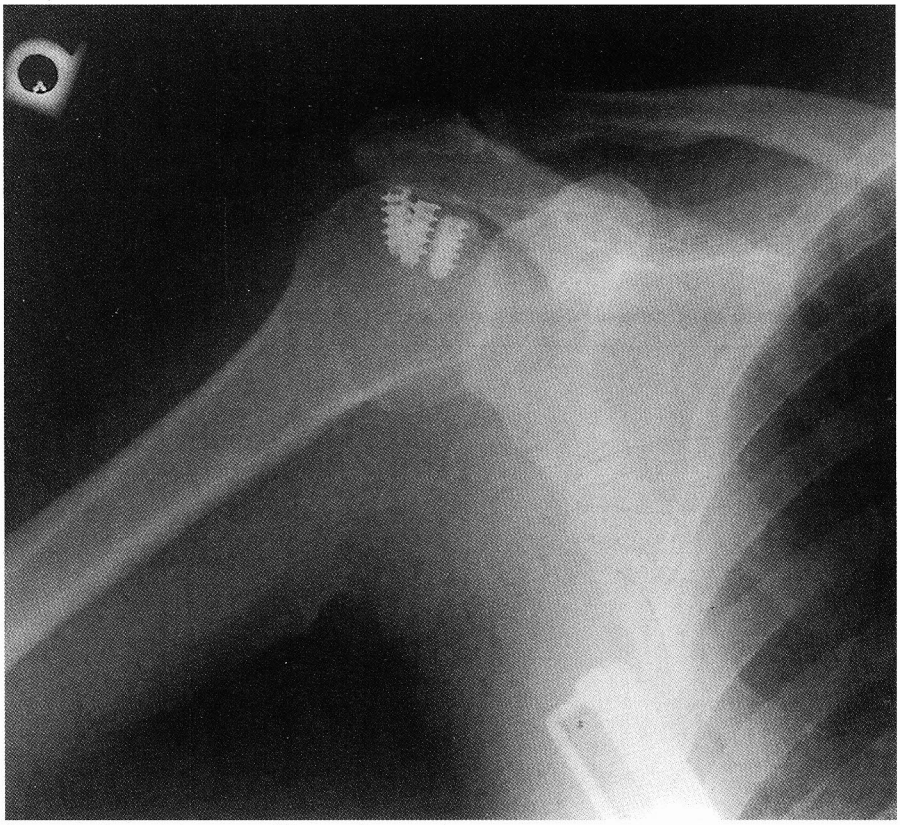

Figure 5a. Use and placement of three anchors.

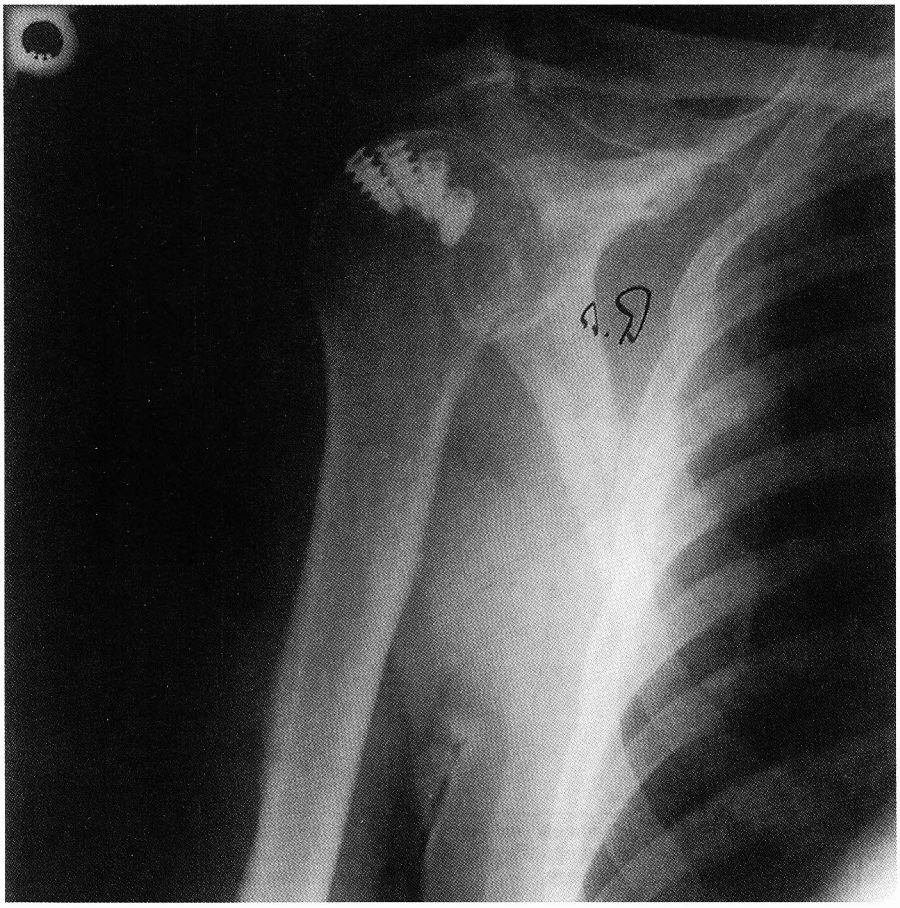

Figure 5b. Use and placement of four anchors.

APPLICATIONS FOR THE SHOULDER

Fifty patients with rotator cuff tears were treated using this new anchor. The indications for surgery and the techniques are as follows.

Indications

Indications for surgery are well known for rotator cuff deficiencies. They include: 1) Night pain refractory to conservative methods, 2) Loss of abduction, 3) Difficulties with daily activities, and 4) MRI or arthrogram proof of rotator cuff tear.[12,13] The operation consists of a decompression of the shoulder with a partial acromioplasty, resection of the acromioclavicular ligament, and repair of the torn cuff. When necessary, the inferior aspect of the acromioclavicular joint was also excised.

Operation

All fifty shoulders had the following operative procedure. The patient is positioned in a semi-sitting position supine on the operating table with the extremity draped free. The incision is begun two centimeters medial to the acromioclavicular joint, laterally to the mid substance, and then distally for approximately three centimeters. The deltoid is split in a vertical fashion and it is detached from the acromion in a superiosteal resection. It is not necessary to remove the anterior or the posterior attachments of the deltoid. The deltoid is split from the anterolateral corner of the acromion between the junction of the anterior and the lateral one-third of the deltoid where there is a well defined raphe of fascial tissues that separates these two areas. An anterior acromioplasty is performed as advocated by Neer. Care is made to avoid injury to the lateral fascial fibers of the deltoid and care is made not to split the deltoid into the fibers of the axillary nerve.

The bursa is removed exposing the tear, usually a V-type, extending into the substance of the supraspinatus tendon. Often, the entire cuff is retracted and requires considerable mobilization. It should be noted that the subdeltoid bursa is frequently quite thickened and can be mistaken for the rotator cuff.

Once the rotator cuff is fully mobilized, the edges are freed of all investing fascia and freshened with a knife or cutting cautery.

Attempts are made to suture the

deepest portion of the supraspinatus into the infraspinatus and the posterior inferior portion of the cuff with multiple sutures of #2 Mersilene. Once this approximation had been made of the cuff, a bone trough is made in the tuberosity of the humeral head. Into this denuded bone as many as four AME Ogden Anchors are inserted at a ninety degree angle from the pull of the tendon (Figure 3). The #2 Mersilene attached to the anchor is then sewn into the central portion of the supraspinatus with the arm held in 15-20° of abduction. The other sutures are then passed through the cuff in such a way as to allow a complete closure of the rotator cuff, giving it a very firm attachment to the humerus. No additional drill holes or other methods were used to repair the cuff to the humerus. The deltoids, subcutaneous layer, and skin are then closed in a standard fashion and the arm placed in an abduction splint. The wound is not drained and cold thermy is used for 24 hours.

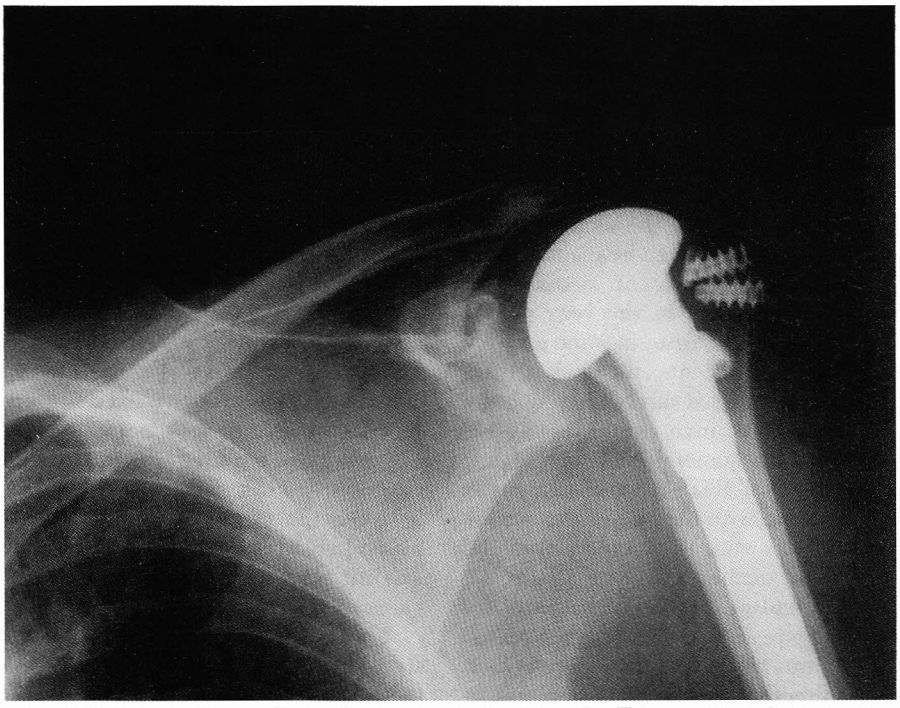

Figure 6. Radiograph of Anchor Used in Conjunction with Total Shoulder. There would have been no way to have reattached this cuff to the bone without the use of the anchors. They made the procedure quite easy to perform and gave remarkably good results from a patient who essentially had no cuff.

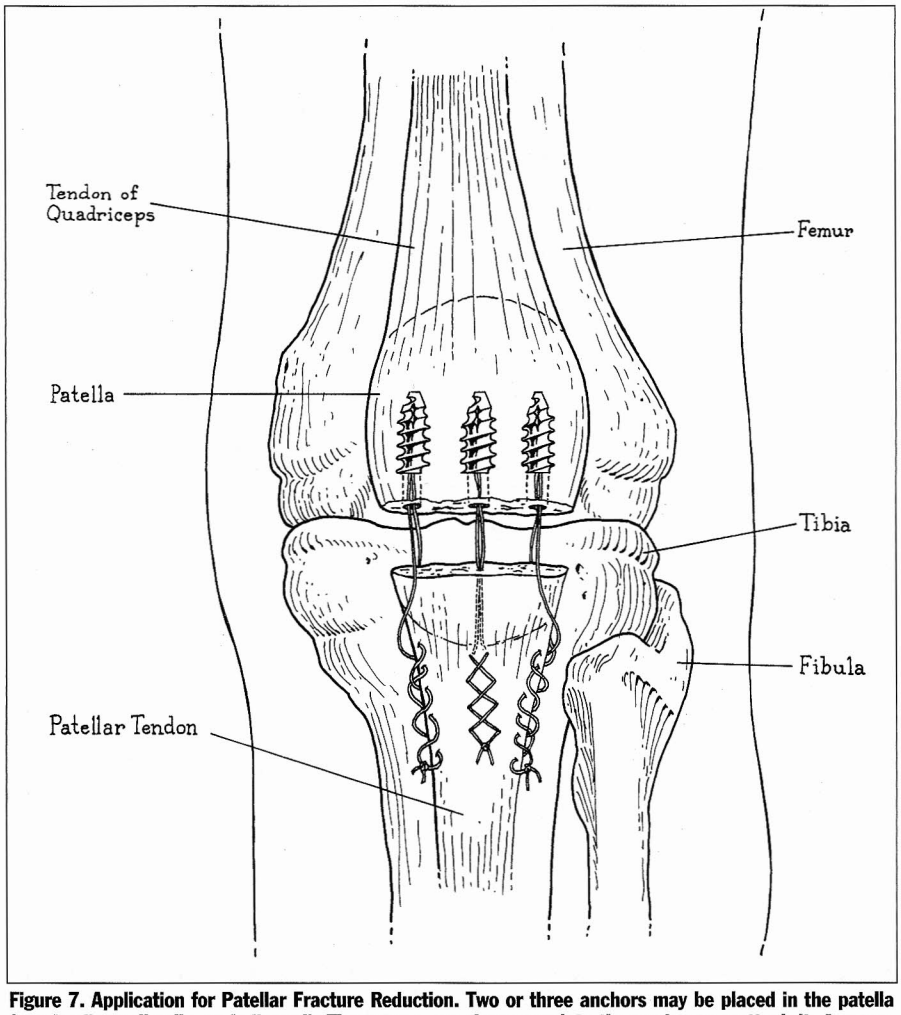

Figure 7. Application for Patellar Fracture Reduction. Two or three anchors may be placed in the patella (proximally or distally, as indicated). The sutures are then sewn into the tendon to reattach it. A suture may be sewn through the fragmented bone to reduce it.

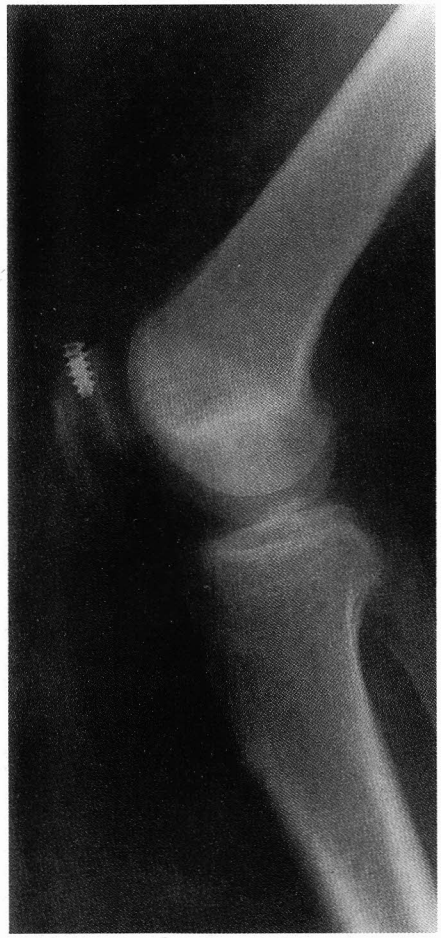

Figure 8. Radiograph of Proximal Patellar Tendon Rupture Repair. Patellar tendon ruptures from the tibia are easily repaired and give excellent results. Even in the young patient, this will afford an excellent method of repairing the patellar tendon.

A note should be made concerning the placement of the AME Ogden Anchor into the greater tuberosity. It is necessary for the anchor to be placed two millimeters beneath the level of the bone surface. This allows the rotator cuff direct attachment to the bone rather than against the anchor itself. While it is desirable to have a thin layer of cortical bone present, occasionally this is impossible in the very osteoporotic shoulder. Also, in some severely osteoporotic patients, the anchor itself should then passed directly through the cortical bone into the more lateral aspect of the humeral shaft (Figure 4a). The angle of this screw placement is then in line with the pull of the rotator cuff. The suture is threaded from the end of the anchor, and is cut so that the ends of suture may be sewn into the cuff (Figure 4b). The cuff is then pulled down into its trough, the suture is then tied directly over the anchor recess so that the knot falls into the cannulated end of the anchor (Figure 4c).

Rehabilitation

The rehabilitation program consists of three formal phases. The first is gentle range of motion with the patient in an abduction pillow for two weeks. Once the sutures are removed, passive, assistive range of motion is then increased to pendulum exercises. All exercises are performed twice a day with the assistance of a physical therapist. After the first two weeks, the patient is given home instruction.

The second phase of rehabilitation consists of active assistive exercises initiated on the third postoperative week and continued until the patient has a full range of motion. This usually occurs between the eighth and twelfth week post-operatively. Terminal stretching during this period of time is also encouraged.

The final phase of exercises is a strengthening program initiated when there is a full range of motion. This is done with light weights and is carried out until the patient is completely pain free.

Results

Of the fifty patients that have been done to this date, forty patients have had excellent to good results, five have had fair results and five have had poor results. The poor results were in those patients who were debilitated and who had difficulty obtaining the expected criteria for full range of motion; however, all fifty patients did have good pain relief. Radiographs of two patients are presented in Figures 4a and 4b using either three or four anchors. These statistics are in keeping with those reported by other authors.

The shoulder is the primary location where the AME Ogden Anchor has been used and the rotator cuff repair has given excellent results. Other uses of the anchor around the shoulder have been in reconstructing the rotator cuff around the total shoulder. A contraindication to performing a total shoulder is the lack of a rotator cuff, yet often the defect is not obvious until the time of surgery. Even when the rotator cuff is

Figure 9. Radiograph of Anchor Used in Conjunction with a Total Knee. The anchor provides excellent support for patellar tendon reattachment.

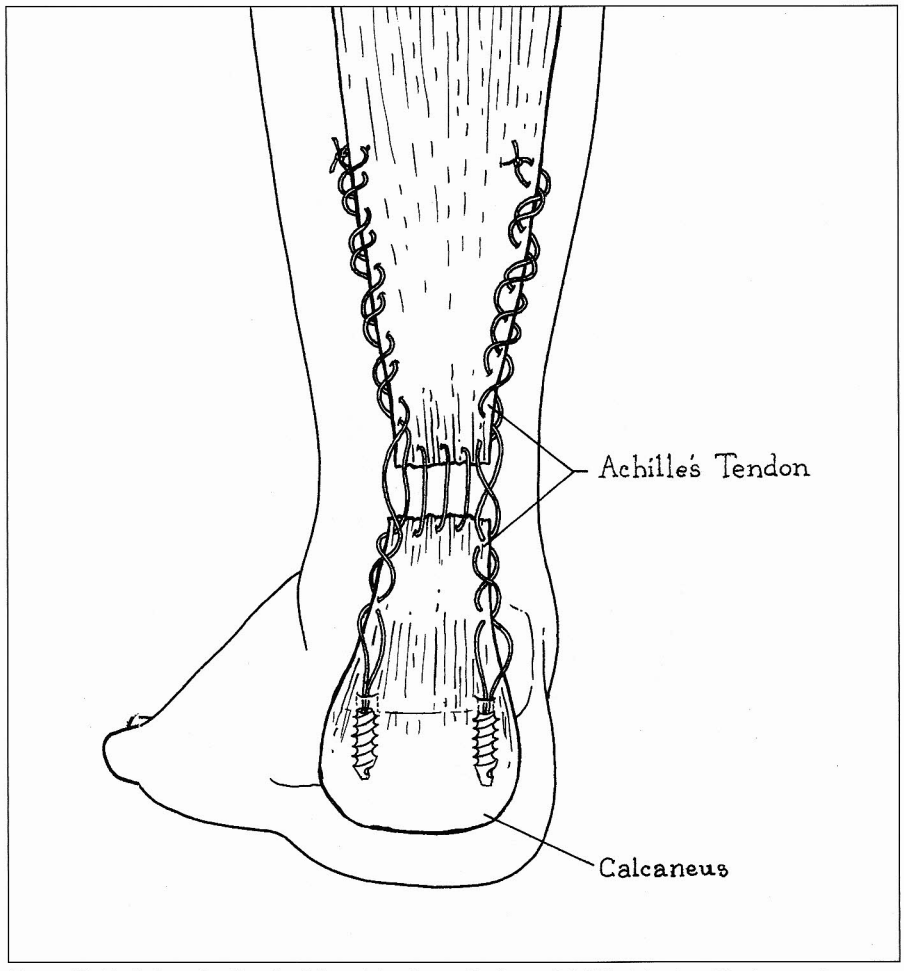

Figure 10. Technique for Repair of Musulotendinous Rupture of Achilles' tendon. The two anchors, are placed laterally, are then sutured with #2 suture through the ligament through the repair in such as way as to afford a very positive and a very strong repair of the Achilles' tendon.

severely contracted, it frequently can be separated from the overlying fibrous tissue and scar and can be successfully reconstructed using the anchor.

The following are case reports of applications of using the anchor in the shoulder.

Case History #1

Rotator Cuff Repair in Total Shoulder Replacement. A seventy-eight year old man had a four-year history of progressive shoulder pain. He had been seen in another clinic and was found to have a rotator cuff deficiency. Attempts had been made to repair the rotator cuff tear with a suture anchoring device. This had failed and progressive arthritis was noted on repeat X-rays of the humeral head. At the time of surgery, it was felt that the rotator cuff was deficient, and attempts to repair the cuff were unsuccessful.

On examination, the patient had abduction only ten degrees with marked pain, flexion to eighty degrees, internal external rotation of ten degrees, all with severe pain. X-rays revealed severe degenerative arthritis involving the right shoulder with a high riding humeral head in relationship to the glenoid. Several small screw-like devices were seen in the cancellous bone of the greater tuberosity.

At surgery, the rotator cuff appeared irreparable, but by careful digital dissection, the supraspinatus, the infraspinatus and the subscapularis portion of the cuff were dissected from the underlying scar tissue. Once these had been tagged, the total shoulder replacement was inserted, then reduction accomplished and using multiple AME Ogden Anchors, the rotator cuff was then brought into anatomical position and sutured into the tuberosity (Figure 6). The areas between the supraspinatus, the subscapularis and the infraspinatus were then repaired with multiple sutures of #2 Mersilene.

Post-operatively, the patient was maintained in an abduction pillow for two weeks and gradual progressive range of motion was instituted until the sixth week when active assistive range of motion was begun. At three months, the patient had full strength of the shoulder. He could abduct eighty degrees, flex to ninety degrees internally, externally rotate to thirty degrees with full function of the rotator cuff.

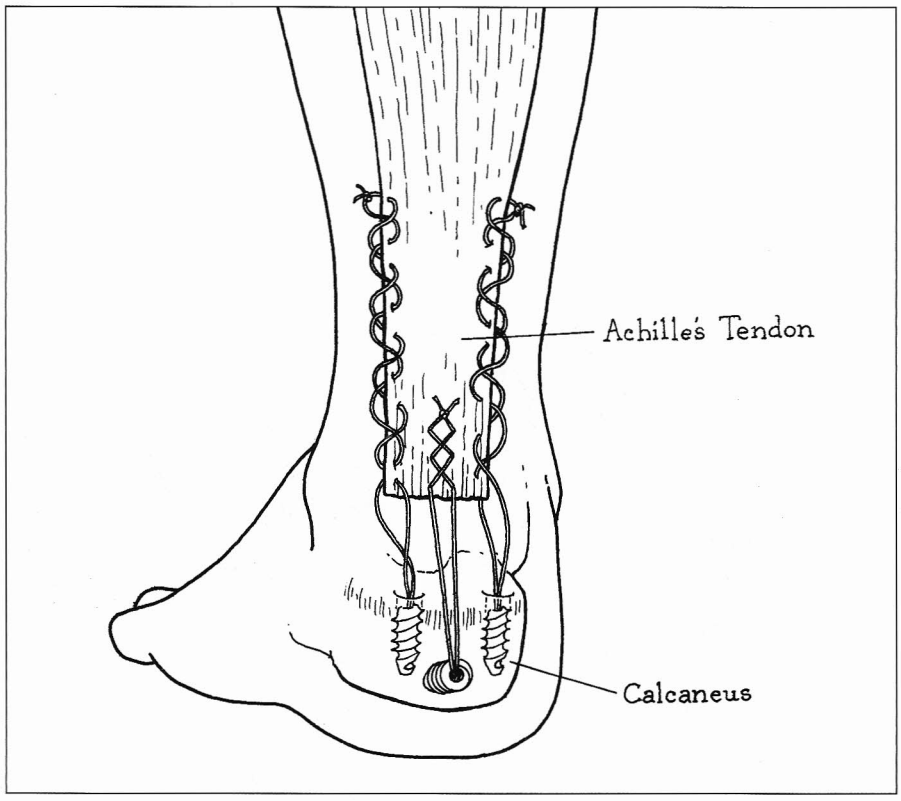

Figure 11. Technique for Repair of Tendocalcaneous Achilles' Tendon Rupture from Os Calcis. Usually three anchors are used for this tear. One anchor is placed on either side of the tendon and one directly at the middle of the insertion. The anchor in the middle is used primarily to repair the tendon to the bone with a figure 8 type suture. The two anchors that are placed laterally are then sutured with #2 suture through the ligament through the repair in such as way as to afford a very positive and a very strong repair of the Achilles' tendon.

Figure 12. Radiograph of Achilles' Tendon Rupture Repair. Three AME Ogden Anchors allow a strong repair of the Achilles' tendon.

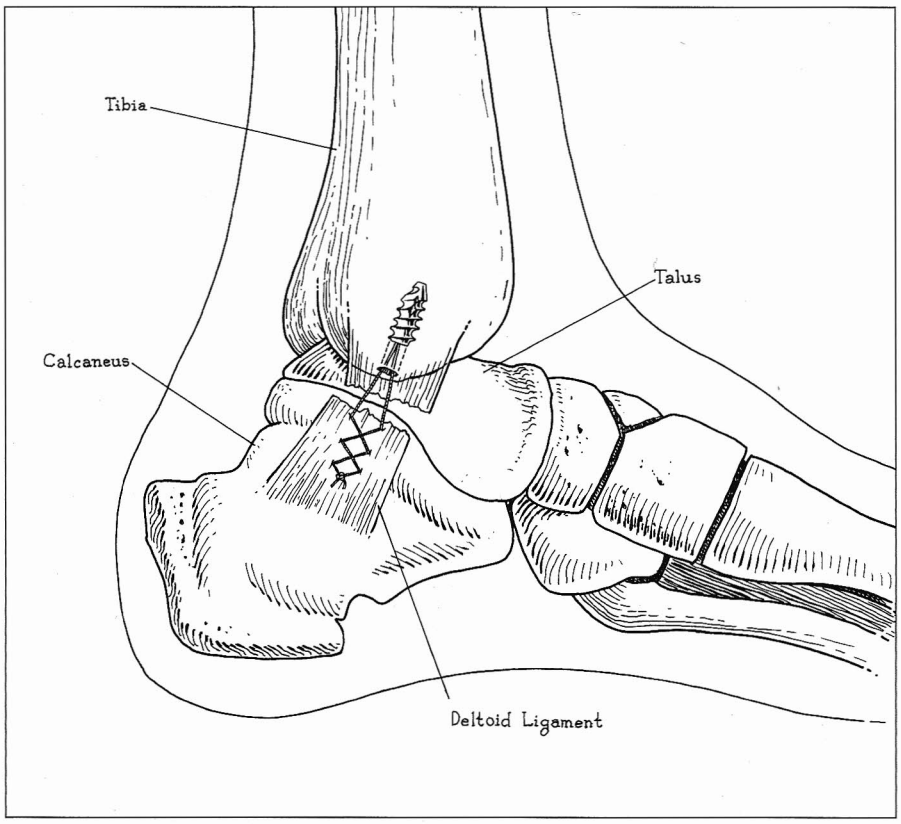

Figure 13. Application of Anchors for Deltoid Ligamentous Avulsion. The anchor is placed in the malleolus and the ligament is secured with the suture.

Figure 14. Radiograph of Deltoid Ligamentous Avulsion Repair. Deltoid ligament repair is simplified with firm fixation of the ligament.

Case History #2

Rotator Cuff Repair in Total Shoulder Replacement. A forty-eight-year-old female with a history of avascular necrosis of multiple joints presented with severe left shoulder pain. She previously had both hips and her right shoulder replaced. X-rays and MRI showed advanced avascular necrosis involving the left humeral head. On examination, she had essentially a full range of motion, but severe pain on abduction which limited volitional abduction to 60°, flexion to 80°, internal external rotation to 10°.

She was taken to the operating room and there had a total shoulder replacement. At the time of surgery, it was noted that the rotator cuff was intact.

Six months following surgery, she developed pain directly over the greater tuberosity and was felt to have an acute impingement syndrome. Despite a conservative regimen, she did not improve. She was taken to the operating room and there had resection of the greater tuberosity, acromioplasty and repair of the rotator cuff in this area using two AME Ogden Anchors. Her postoperative course was unremarkable. She regained full range of motion within three months with good strength.

Acromioclaviclar Dislocations

Another use of the anchor has been in chronic acromioclavicular dislocations. An effective way to decompress the distal clavicle and hold it firmly against the coracoid process is by placing the AME Ogden Anchor directly into the coracoid process, and attaching the sutures directly to the clavicle. This method allows some mobility, and acts as a strong tether to the distal clavicle. When used in association with pins passed through the acromion into the clavicle, this has proved to be an excellent method for reduction of the AC joint. Once healing is complete, the acromion pins are removed.

The anchors work effectively in cases where there is marked fragmentation of the upper part of the humerus with separation of the greater tuberosity from the humerus.

APPLICATIONS FOR THE KNEE

The AME Ogden Anchor is useful when repairing patellar fracture or patellar tendon ruptures. Patellar fractures with comminution of the inferior pole of the patella are easily repaired

using the AME Ogden Anchor. The anchor is inserted into the proximal fragment and the #2 Mersilene attached to the anchor is then passed through the patellar tendon affecting a strong repair (Figure 7). Use of the anchors in repairing these fractures or avulsions of the patellar tendon from either the proximal or the distal portion of the patella affects excellent repair and allows early mobilization.[14,15,16,17]

Case History #3

Patellar Fracture. A thirty-eight year old male was involved in an automobile accident and presented in this Emergency Room with marked comminution of the inferior pole of the patella. There was complete disruption of the patella with separation of the patellar tendon. No other abnormality was noted.

The patient was taken to the operating room and there had resection of the multiple small fragments of the inferior pole of the patella. Three AME Ogden Anchors were then passed into the body of the proximal portion of the patella and #2 Mersilene was then sutured into the patellar tendon effectively repairing it to the proximal portion of the patella (Figure 8). Post-operatively, the patient was maintained in splints for four weeks and then gradual range of motion and quad setting exercises were begun. By three months, he had a full range of motion and excellent strength of his quadriceps with excellent maintenance of the integrity of the quadriceps mechanism.

When there is fragmentation of one pole of the patella, this can be excised. The anchor is then placed into the remaining fragment and sutured into the patellar tendon. This should probably be the method of choice in repairing fractures or avulsions of the patellar tendon from the patella.

Case History #4

Patellar Tendon Rupture. A twelve-year-old male presented in the emergency room with inability to straighten his knee. X-rays revealed that the patellar tendon insertion had avulsed from the tibia. He was taken to the operating room and there he had the tendon placed back into the avulsed bed with two AME Ogden Anchors. The suture was passed through the bone and then into the patellar tendon affecting a very strong repair of this rupture. Postoperative course was unremarkable and he obtained full healing and range of motion within three months.

The AME Ogden Anchor is effective in ligamentous reconstructions about the knee. Classic triads when the medial collateral ligament is torn from either the tibia or the femur are excellent places to use the anchor. The techniques for this are exactly like the techniques for the shoulder. Both the tibia and femur have primarily cancellous bone in this area. The anchor allows

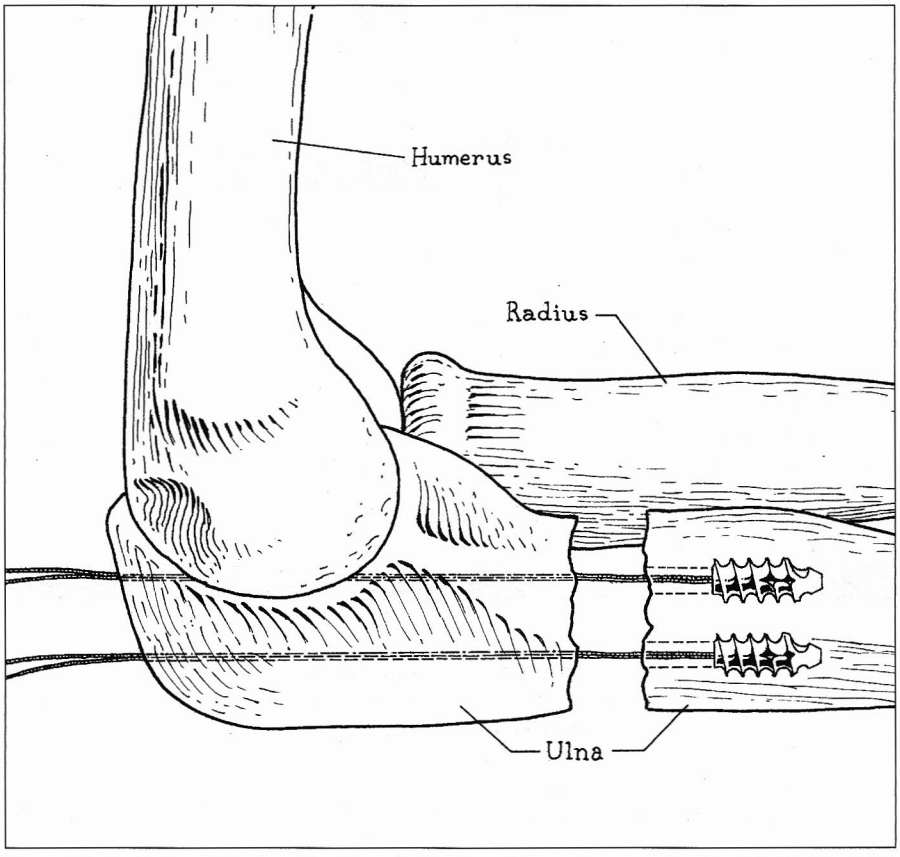

Figure 15. Application of Anchors for Olecranon Fracture. Two anchors may be placed in the fractured radius and the suture used to reduce the olecranon fragment.

Figure 16. Radiograph of Olecranon Fracture Reduction. Wire suture has been attached to the anchor.

excellent support for suture into the bone.

Another excellent use for the AME Ogden Anchor may be in conjunction with total knee replacements. When the patella is everted laterally to allow access to the knee, the insertion of the patellar tendon frequently is partially torn away from the tibial tubercle. Reattachment may be accomplished by inserting either one or two into the tibial tubercle. Then, once the total knee has been performed, the #2 Mersilene is then sutured into the patellar tendon affecting a strong repair of the tendon to the bone (Figure 9).

The AME Ogden Anchor is also very useful in the Hauser procedures as a method to assure the patellar tendon and bone is held snugly in place. When the patellar tendon is split, and one half is pulled medially, an anchor is very effective in holding the tendon in place. The anchor has also been used to attach homologous graft to the tibia in anterior cruciate ligament repair.

APPLICATIONS FOR THE ANKLE

The Achilles' tendon, whether ruptured in its musculocutaneous junction (Figure 10), or avulsed from the os calcis (Figure 11), affords a good place for the anchor to be used.[18,19,20,21] Usually three anchors are used for a tear. One anchor is placed on either side of the tendon and one directly at the mid area of the insertion, and is used primarily to repair the tendon to the bone with a figure 8 type suture. The two anchors that are placed laterally with a #2 suture are then sutured through the tendon in a Bunnell-type repair in such as way as to afford a very positive and a very strong repair of the Achilles' tendon.

Prior to the availability of the anchors it was necessary to use a pull out type of wire through a button over the heel, or by doing musculotendinous flaps for the repair. Use of the anchor is both easy to use and will allow early mobilization because of the positive repair that is obtained by using the #2 Mersilene anchored securely to the os calcis (Figure 12).

The AME Ogden Anchor is useful in severe trimalleolar fractures, in which the fibula is fractured above the malleolus, and there is avulsion of the deltoid ligament from the medial malleolus (Figure 13). In attempting to repair the avulsed deltoid ligament, there is usually very little soft tissue in which to suture the avulsed ligament. Use of the anchors simplifies the method whereby the avulsed deltoid ligament can then be everted and then attached firmly to the bone (Figure 14).

APPLICATIONS FOR THE ELBOW

Fractures of the olecranon can easily be repaired by using the AME Ogden Anchor, by inserting the anchor into the more distal portion of the ulnar and passing the suture through drill holes to the proximal fragment (Figures 15 and 16).[22,23,24] This gives a positive repair and allows early mobilization. The anchor works well for repairing the triceps to the olecranon following total elbow replacement.

CONCLUSION

The re-attachment of soft tissue to bone has been a long-standing problem in orthopedic surgery. Bone anchors provide a better way of accomplishing soft tissue attachment as compared to older methods of drilling and sewing the tendon to bone. One bone anchor with a headless, deeply-threaded corticocancellous design is superior in pullout strength to competitors and provides simplicity of insertion and removal. The design also lends itself to applications in fracture management and dislocations. STI

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