**Transposition of Muscle and Tendon**

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- Transposition by Osteotomy at the Insertion
- Transposition of Muscle or Tendon Without Tenotomy
- Transposition of Muscle or Tendon by Terminal Tenotomy
- Free Tendon Transplantation

Transposition is the transfer of a tissue flap from one location to another without complete severance of its attachments, vascular supply, and innervation. Transplantation is a term used to include removal or partial detachment of a part of the body and placement into or on the same or another individual. Transposed tendons are, in the broadest sense, transplants. Transpositions are always viable autografts, whereas transplants may be viable or nonviable and may be autografts, allografts, or xenografts. In addition, transplant grafts may be classified as follows:

- Anastomosed: The circulation of the host is reestablished in the graft by vascular anastomosis.
- Pedicled: The graft is connected to the host at least temporarily by a pedicle containing blood vessels.
- Free: Tissues are devoid of vascular, nervous, and lymphatic connection at the conclusion of the procedure.
- Infused: The graft is established by an infusion of cells into the bloodstream, a body cavity, or tissues of the host.

Free or nonviable muscle grafts will not survive as such but are replaced by fibrous tissue. Nevertheless, free muscle grafts are useful to control hemorrhage during neurosurgery and to aid incision of atrial septal defects. Free tendon grafts are used in humans to restore function to damaged hands and feet. These freegrafts heal by vascularization from adjacent tissues and through sutured tendon ends. Anastomosed muscle and tendon grafts have been described in animals. Microvascular and neural anastomotic techniques require special equipment and exceptional technical skills and practice but promise the most definitive and successful form of transplantation in the future. Anastomosed grafts of proper size and function may be placed without transposition of agonist or antagonist muscle tendons. Transposition of muscle and tendons has been used extensively for the treatment of orthopaedic and peripheral nerve diseases in humans and animals. Dynamic tendon transpositions may be used in orthopaedic disease such as distal and caudal transposition of the greater trochanter of the femur in coxofemoral luxation. Nevertheless, most tendon transpositions for orthopaedic disease are static transplants, with no propensity for active contraction. With such rare exceptions as the support of the commissure of the mouth in facial paralysis in humans, dynamic tendon transfers are not used in peripheral neuropathies.

Knowledge of the structure and healing of tendons (Chapter 4), meticulous attention to detail, and atraumatic technique are most important in dynamic tendon transpositions. Less attention to detail may be acceptable in static tendon transpositions, although maintenance of adequate vascularity and suture fixation until healing occurs is important and should preclude careless techniques. Tendon that is deprived of its blood supply will undergo cellular necrosis in 9 days. Collagen bundles lose their cohesiveness after 2 to 3 weeks.

Other factors may determine the ideal donor for tendon transposition. The donor organ should be present in all animals of the species intended for application, consistent in dimensions at least in proportion to size of the animal, of sufficient length and thinness for adequate vascularization yet strong enough for the task intended. In addition, the donor tendon should be conveniently located in relation to the site of application and preferably superficial. Its use should not adversely affect function at the donor site.
In dynamic tendon transfer, the donor muscle must be strong enough to perform the function of the muscle reasonably well or to supplement the strength of a partially paralyzed muscle. The excursion of the muscle should be similar to the one replaced or reinforced. Agonist muscles, having action similar to the muscle replaced, are preferred. Antagonist muscle may be used if necessary.

To retain function, the transposed end should be attached close to the insertion of the paralyzed tendon and should be routed in a straight line, as much as possible, between origin and insertion. The donor tendon sheath should be maintained or the tendon should be inserted into the sheath of another tendon. If neither sheath is available, as much fat as possible should be retained around the recipient site. Tendon placement through tunnels in bone or fascia encourages adhesion and is contraindicated in dynamic tendon transposition. The nerve and blood supply of the donor muscle should not be impaired by excess tension or surgical manipulation. The transferred tendon should be securely attached to bone or to the end of the severed recipient tendon under slight tension.(17)

In addition, the affected joints must have reasonably normal function. All contracted tendons and restricting adhesions should be released before tendon transposition. Although catgut may encourage inflammation at the site of attachment of donor and recipient tendons, it also tends to incorporate surrounding tissues, thus decreasing function, and suffers loss in tensile strength too rapidly for tendon healing. Nonabsorbable monofilament sutures such as stainless steel wire, polyethylene, or nylon are preferred.

The compilation of reports of tendon transpositions that follows is extensive but incomplete.(15) The most commonly used techniques are presented as examples. Some others are included because of their innovative approach. No technique has been excluded editorially. Many may be found more adequately described elsewhere in this text.

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**Transposition by Osteotomy at the Insertion**

Osteotomy of the insertion site of functioning muscles is used to realign the long axis, reposition the insertion, and increase the effective action or muscles.

An increase in tonic muscle action has been advocated in coxofemoral luxation as a supplement to surgical exploration and reduction of luxation of the femoral head. A trochanteric osteotomy was performed in the approach to the coxofemoral joint. Debridement of the acetabulum, reduction of the femoral head, and repair of the joint capsule were routine. The greater trochanter was reattached caudal and distal to its normal position. A wedge of bone may be removed from the metaphyseal portion of the osteotomy site before the trochanter is fixed with a tension band.

Transposition of the insertion of the common patellar tendon by tibial tuberosity transplantation has been used as a step in the repair of patellar luxation.(29) The tuberosity was separated and elevated with an osteotome and a new bed made by removing the periosteum and scarifying the cortex of the tibia adjacent (lateral in medial patellar luxation) to the deviated tuberosity. The tuberosity was transposed to the debrided area and fixed with Kirschner wire, stainless steel wire suture, or an orthopaedic screw. The procedure, when combined with femoral trochlear chondroplasty and/or construction of a lateral patellar ligament, realigns the direction of the common patellar tendon in the trochlear groove to the proximal tibia.

A static tendon transposition was described by Jones(11) for use in humans and adapted to animals by Duelands and Strande(27,28) for repair of cruciate ligament rupture. A patellar wedge was produced from the central portion of the patella and the incisions continued to free the midline portion of the common patellar tendon. A tunnel was drilled through the lateral condyle to the tubial tubercle in the intercondylar fossa of the femur. The proximal end of the tendon was inserted proximally through the tunnel and sutured to the head of the gastrocnemius tendon.

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**Transposition of Muscle or Tendon Without Tenotomy**

Transposition of muscle without tenotomy has been described for cruciate ligament rupture,(8) patellar luxation,(21) and shoulder luxation,(10)

Static transposition of the long digital extensor was described by Hohn and Miller(8) for repair of a ruptured cranial cruciate ligament. A lateral parapatellar incision was made and the long digital extensor tendon lifted and transposed to a trough cut in the lateral one-third of the tuberosity cranial to the normal position of the extensor. The tendon was fixed in
this position with stainless steel wire.

The tendon of origin of the biceps muscle may be transposed medially or laterally for the respective luxation of the shoulder to form a collateral ligament at the point of weakness. (10)

In the treatment of medial luxation, an approach is made by incision of the insertions of the superficial and deep pectoral muscles and the subscapularis muscle. The transverse humeral ligament, which retains the biceps tendon, is severed. The biceps tendon is transposed medially and caudally and fixed in a trough in the lesser tubercle. The bone flap that was lifted to make the trough and the tendon are fixed with small pins. (See Figs. 21-8, 21-9, 21-10, 21-11, 21-12.) Following transposition, the subscapularis and pectoral muscles are reattached.

The biceps tendon is transposed laterally for lateral luxation. The insertions of the pectoral muscles and the transverse humeral ligament are incised. (See Fig. 21-18.) An osteotomy of the greater tubercle is performed and the tubercle and supraspinatus muscle reflected proximally. The biceps tendon is reflected lateral to the greater tubercle, and the tubercle is reapposed and fixed. Partial incision of the dorsal edge of the deltoid muscle may be necessary for proper placement of the biceps tendon. The pectoral muscle incisions are sutured. Lateral transposition of the biceps tendon without fixation creates a dynamic tendon transposition.

Transposition of Muscle or Tendon by Terminal Tenotomy

Most muscle/tendon transpositions used to treat neurologic deficits incorporate dynamic transposition with realignment of the muscle and tendon. In most, complete muscle action is required and achieved by terminal tenotomy.

Flexor tendon transposition has been used in radial-brachial paralysis. (See Chapter 66.) Functional integrity of the muscle transposed and of at least one other flexor with similar action is a prerequisite to successful surgery. Extension of the carpus and digits is obtained by transposition of the tendon of the flexor carpi radialis distal to the muscle belly to the tendon of the denervated common digital extensor muscle. (25) (See Fig. 66-5.)

Extension of the elbow is achieved by transposition of the biceps brachii (12) or the brachialis (14) muscle to the olecranon. Although the tendon of insertion of the biceps offers greater support, a medial approach is necessary for transposition and is technically more difficult. The brachial muscle may be transposed lateral to the humerus following transection as near the insertion as possible. (See Fig. 66-6.) Blunt dissection is used to free the distal muscle while maintaining blood and nerve supply. The lateral head of the triceps is separated from the anconeus muscle and retracted caudally to expose the olecranon. The tendon is fixed to the olecranon by stainless steel suture placed in a modified Bunnell pattern in the brachial muscle and threaded through two holes drilled in the olecranon. The muscle is then sutured to the long and medial heads of the triceps tendon with simple continuous sutures, and the lateral head of the triceps is resutured. Immobilization in extension is maintained for 3 weeks after surgery. Weightbearing is gradually increased over the next 3 weeks.

A similar distal transposition was described for the correction of fibular nerve paralysis. (2) In the procedure, a functional flexor, consisting of one or more units of the deep digital flexor, was transposed to the long digital extensor muscle or tendon and attached by side-to-side anastomosis. The long digital flexor, the small medial portion distal to the popliteus, or the caudal tibial, a weak muscle located deep to the long digital flexor, was transposed through a medial approach (Fig. 71-1). The tibial branch of the sciatic nerve must be intact.

Lesser (18) described a unique transposition for sciatic paralysis in a dog, combining anastomosis of the tendon of origin of the long digital extensor with the vastus lateralis muscle, overlap shortening of the tendon of insertion of the long digital extensor, and lengthening of the contracted superficial and deep digital extensors. The latter two procedures were performed to facilitate the dynamic transposition of the vastus. In the first procedure, the tendon of origin of the long digital extensor was detached from the lateral femoral condyle (Fig. 71-2). The vastus lateralis was freed cranially and caudally by sharp incision and blunt dissection from the patella proximal to the middle third of the femur. The tendon of the long digital extensor was threaded through stab wounds in the fascia of the vastus lateralis and sutured with 4-0 nylon. When this technique was completed, the vastus lateralis was an active extensor of the digit, mediating its action through the long digital extensor muscle and tendon, which acted as the tendon of insertion.

Dynamic transposition of the sartorius muscle has been used in repair of cranial cruciate ligament rupture. Tenotomy of the muscle insertion is a fasciotomy because the muscle inserts through broad, flat fascia. In one technique the distal fascia of the sartorius and the biceps muscles is dissected and the muscles transposed distally. The insertions are sutured in...
common to the tibial crest, creating a sling of muscles that forces the tibia caudally during contraction. Similar transposition of the biceps fascia has been used in patellar luxation.\(^6\)


Hohn and Newton\(^9\) described a craniomedial parapatellar incision for medial meniscectomy. Following meniscectomy and closure of the medial arthrotomy, the insertion of the posteriorsartorius was sutured to the common patellar tendon. A lateral parapatellar incision and posterior lateral capsulorrhaphy were used to complete the repair of the cranial cruciate ligament. Transplantation of the cranial head of the sartorius muscle was described by Horne\(^11\) for medial patellar luxation. A medial approach was used to free the cranial portion of the sartorius. A cranialateral parapatellar incision was used for trochlear chondroplasty and the joint capsule apposed. The cranial sartorius was sutured to the lateral fascia proximal to the patella to redirect its effect on the patella. Mattress sutures were placed through the patellar ligament and lateral retinacular fascia to reposition the distal end of the common patellar tendon, and the lateral incision was closed. The medial fascial defect was not closed.

Puget and Cazieux\(^22\) described a similar technique for traumatic medial luxation of the patella in 1963. A lateral parapatellar incision was made to free a rectangular portion of the insertion of the fascia lata tendon. The parapatellar incision was closed with tension sutures to pull the patella laterally, and the fascia lata was transposed proximal to the patella and sutured to the medial parapatellar fascia.

Static transpositions of muscle fascia and tendons have become commonplace. Repair of cranial cruciate ligament rupture has been reported with static transposition of the peroneus tertius\(^23\), the long digital flexor\(^27,28\), part of the common patellar ligament and the retinacular fascia\(^1\), and the fascia lata.\(^16\) It is ironic that one of the latter was the standard technique for and subject to minimal variations\(^1\) while the other resulted in one of the few published techniques for cruciate ligament repair that failed.\(^16\)

In Paatsama’s modification of the Hey Groves technique, the fascia from the flank to the level of the lateral condyle was freed from underlying tissue and a long rectangular strip was cut proximally but remained attached distally.\(^19\) (Although classified as a terminal tendon, the fascia was actually harvested from the insertion fascia by incision between muscle and fascia without disruption of the fascial insertion.) The loose end of the fascial strip was introduced through a tunnel from the lateral condyle of the femur to the intercondylar groove and continued through a similar tunnel from the proximal tibia to the distal point on the craniomedial surface of the tibia. The ligament was tightened and sutured to the common patellar tendon or fixed to itself after passing through a small hole in the tibial crest. Paatsama later modified the technique by extending the incision so that the fascia remained attached only at the tibial crest distally, thus adding length. Others emphasized modification such as return of the end of the fascia through the tunnel in the tibial crest to suture the end of the new ligament to its origin.\(^29\) Arnoczky, utilizing a base of information resulting from biomechanical studies, constructed a transposed ligament from the common patellar tendon and adjacent retinacular fascia.\(^1\)

The fascia has been used for construction of a lateral patellar ligament and replacement of the lateral collateral ligament. In the former, a fascial strip was dissected proximally and remained attached to the lateral equator of the patella.\(^24\) The end of the fascial strip was placed through a tunnel in the origin of the lateral gastrocnemius tendon and reflected on itself. Sutures were used to fix the tendon to itself at this point. In the latter, Paatsama fabricated a fascial strip lateral to the patella.\(^24\) The fascia was fixed with sutures to a screw placed at the proximal end of the lateral collateral ligament as well as at the attachment of the lateral collateral ligament on the head of the fibula (Fig. 71-3). The author modified these techniques for dogs with medial patellar luxation. Lateralparatellar fascial strip was formed and fixed with wire suture to the origin of the lateral head of the gastrocnemius tendon. The suture encircled the fabella. The fascial strip was then continued distally and attached, under tension, to the commonpatellar tendon at its insertion on the tibial crest. The resultant transposed fascial strip formed a lateral patellar ligament and prevented medial rotation of the tibia.
Free Tendon Transplantation

Free transplants have rarely been used in orthopaedic repair in the dog and cat. A unique tendon (ligament) allograft was used by Milton and others for cranial cruciate ligament replacement in the dog.* In this technique, the cruciate ligament was harvested from donor dogs by plug osteotomy of the proximal and distal attachments. The allograft was transplanted into appropriate beds drilled in the femur and tibia of recipient dogs in whom the cruciate ligaments had been removed. The bone plugs at the ends of the ligament were fixed with Kirschner wires. Bone and ligaments vascularized in the recipient dogs, producing minimal to no lameness at the end of the trial and only rare cartilage hyperplasia and synovitis.


References


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