Surgical Technique

Plantaris Tendon Graft for Atrioventricular Valve Repair

A Novel Hypothetical Technique

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Heart valve repair is a biomaterial-dependent procedure, yet autogenous tissue for valvular reconstruction has to date been obtained mostly from the pericardium and fascia lata. Most clinical studies recommend valve repair as an alternative to replacement. We now put forward a hypothesis, extrapolated from hand surgery, for use of the plantaris tendon in heart valve repair. This proposal, if implemented, would increase the supply of autogenous donor tissue for valve repair, thereby enhancing the surgeon's armamentarium. The report describes a novel technique that in our judgment warrants future clinical development. ***(Tex Heart Inst J 2003;30:42-4)***

Autogenous tissue such as pericardium and fascia lata has been considered suitable for reconstruction of the annulus during valvular heart repair.[1] Given the benefits of valve repair for mitral regurgitation, in comparison with valve replacement, every patient should be considered for possible mitral valve repair.[2] Our search of the English medical literature indicates that tendon transfer for repair of the heart valves has not been reported, yet tendon grafts are used frequently in other musculoskeletal specialties, such as plastic and hand surgery.[3]

In human beings, the plantaris tendon is a rudiment of a large muscle, which in some of the lower animals is continued over the calcaneus and inserted into the plantar aponeurosis. In cows and sheep, the plantaris is a major muscle, from which most xenograft material is obtained.

In man, the plantaris is accessory to the gastrocnemius muscle, extending the ankle if the foot is free, or flexing the knee if the foot is fixed. Removal has no effect on normal limb function.[4] The plantaris is situated between the gastrocnemius and the soleus. It arises from the lower part of the lateral prolongation of the linea aspera, and from the oblique popliteal ligament of the knee joint.[4] At the knee, it forms a small (ca. 7 to 10 cm) fusiform belly that becomes a long, slender tendon as it crosses obliquely between the 2 muscles of the calf and runs along the medial border of the tendo calcaneus, to be inserted with it into the posterior part of the calcaneus (Fig. 1).[4] The tendon is absent in 9% of the population upon ultrasound study.[5]

The plantaris tendon is an extremely tensile structure used for flexor tendon replacement in hand surgery, and it is not too thick for revascularization at the graft site. The epitendineum cells migrate into the wound and initiate the repair process with phagocytosis.[6] Collagen synthesis is a function of the endotendineum cells. Tendon grafts are relatively avascular and initially derive their nutrition by diffusion. Strong clinical evidence from animal data emphasizes "secondary" revascularization in tendon grafts, rather than primary. Secondary revascularization occurs by ingrowth of capillaries to establish a new vascular network. The 2 most important reported complications regarding the use of plantaris tendon grafts in hand surgery are disruption of the tendon at its junction and the formation of adhesions. The former is determined by surgical technique, while the latter is associated with tight junctions. The human plantaris is a high-stress tendon (–36 mPa),[7] whereas human hand tendons have low stress in life (10 mPa).[8] Given these properties, healing is hypothetically maximized and scar formation minimized (in comparison with other prosthetic devices) when a plantaris tendon graft is bathed in ventricular blood.

This report addresses itself to the procurement and use of plantaris tendon. We describe a novel technique for its application to valve surgery, which is both hypo-

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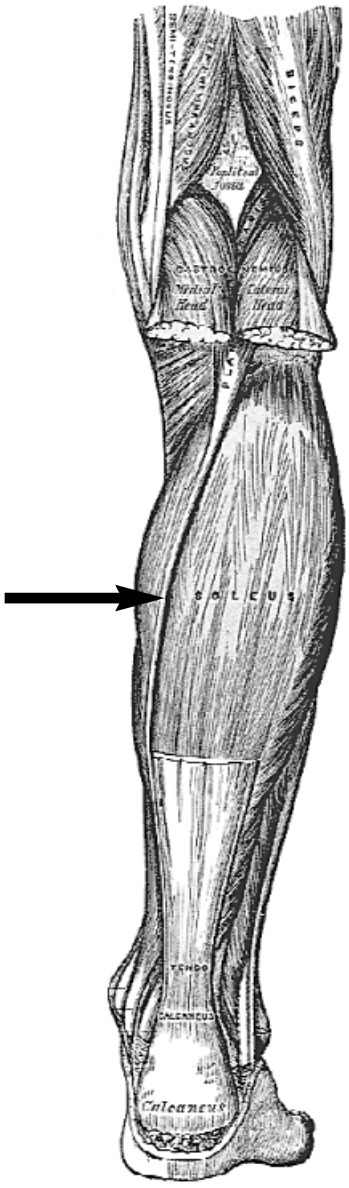

Fig. 1 *The plantaris tendon.*

(From: Gray's Anatomy.[4] *Reproduced by permission of Bartleby.com.)*

thetically sound and highly practical when other prostheses are not available or are contraindicated.

Description of the Procedure

To avoid unnecessary surgical exploration, the patient who is under consideration for repair of either atrioventricular valve undergoes ultrasonography of the calf to determine whether the plantaris tendon is present and of sufficient thickness for grafting.[5]

To harvest the plantaris, a 2- to 3-cm incision is made anterior to the achilles tendon on the medial aspect of the ankle 1 cm proximal to the most proximal part of the calcaneus. The plantaris tendon, which usually lies close to the medial aspect of the calcaneus, is divided. A Brand tendon stripper is slipped over the free end of the tendon and advanced under tension for approximately 20 to 25 cm, until the cutting edge strikes the belly of the plantaris muscle (Fig. 2).[9]

The tendon, once harvested, is stretched horizontally between 2 hemostats so that surplus paratenon can be trimmed. After irrigation of the tendon with a heparin–saline solution, the chordae are replaced with double-armed, pledget-supported plantaris tendon or with individual plantaris fascicles (Fig. 3). Upon exposure of the mitral valve, annuloplasty sutures with pledgets are passed through the tendon. The overall reduction of the annulus is established by measuring the posterior margin of the Carpentier-Edwards ring sizer (the ring sizer having been chosen to match the anterior leaflet size). After repair, the mitral valve is tested by means of saline injection through the aortic root. The plantaris tendon can be treated intraoperatively with glutaraldehyde, for fixation.

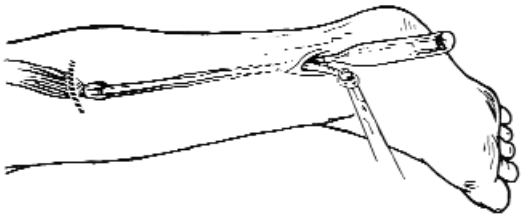

Fig. 2 *Excision of the plantaris tendon with the Brand tendon stripper.*

(From: McCarthy's Plastic Surgery.[9] *Reproduced by permission of W.B. Saunders.)*

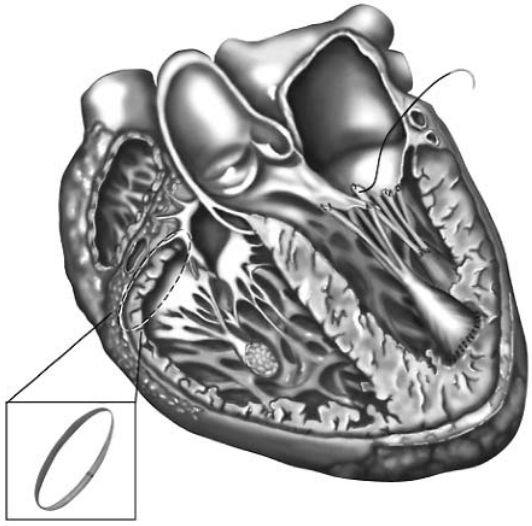

Fig. 3 *Cross-section of the heart illustrates replacement of the papillary muscle, chordae, or both with plantaris tendon. The oval indicates placement of an atrioventricular annulus made from plantaris tendon.*

(Illustration by Adrienne J. Boutwell, MAMS)

Commentary

The advantages of mitral valve repair, in comparison with replacement, include the avoidance of chronic anticoagulation, suboptimal hemodynamics, and potential infectious complications, all of which are associated with prosthetic ring annuloplasty. Also, retention of the native mitral valve apparatus is important in maintaining normal left ventricular geometry.[10]

Tendon tissue, due to its bulk and its smooth surface, can even be used to perform an annuloplasty. Splitting or lateral stretching encourages collagenous adhesions that in theory can provide superior dynamics through an anatomic onlay that surpasses a synthetic onlay. Moreover, the availability of the plantaris makes it an inexpensive source of material to cover tissue defects after removal of calcified atrioventricular valves, which should render plantaris tissue of particular use in resource-poor nations.

The fascicles of tendon (and indeed the fibrils) can move, to some extent, separately from their neighbors and can therefore be used to replace lax or ruptured chordae of the tricuspid or mitral valve. The replacement of chordae with rolled-up pericardium has been described,[11] but that procedure is technically more demanding, yields irregular results,[12] and has not gained wide acceptance among surgeons. If one applies to the plantaris graft the techniques described by Carpentier,[13] the tendon can be partially split for attachment to both papillary muscle and valve leaflet.

Healthy and durable autologous tissue is biologically superior to artificial tissue, but preliminary animal studies need to be performed to delineate the role of plantaris tendon graft in modern cardiac surgery.

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Editorial Commentary

The plantaris muscle in most cadavers is a tendinous string with a small muscle belly proximally. Its resemblance to a nerve has caused such frequent confusion in the dissecting laboratory that the plantaris has been called the "freshman's nerve." There is a syndrome involving rupture of the vestigial muscle after sudden effort, which causes sharp and intense pain in the upper calf, together with local hemorrhaging.

To use this tendon for mitral repair seems unnecessary, since synthetics such as polyester fabrics (e.g., Dacron) heal well and are durable. For the mitral annulus, many collars or rings are commercially available. I use a small piece of knitted, tubular, vascular graft as an annular ring.

As the authors point out, the plantaris tendon is absent in 9% of patients, and needless surgical exploration should be avoided. Use of the plantaris tendon for tendon replacement in hand surgery may be the only logical or practical use.

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