

The Role of Palmaris Muscle Tendon in Mitral Valve Annulus Reconstruction: A Novel Technique for Mitral Valve Repair

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ABSTRACT

Background: Autogenous tissue for heart valve repair is limited to pericardium and fascia lata. Prosthetic annuloplasty rings have limitations and are expensive. No previous cadaveric study has documented autotransplantation of forearm tendons for mitral valve repair. The purposes of this anatomical study were (1) to determine the feasibility of using tendons for annular reconstruction during mitral valve repair (band or ring shape) and (2) to compare the metric dimensions and gross morphology with those of prosthetic rings.

Methods: The palmaris tendon (PM) (n = 7) was harvested from forearms of human cadavers and prepared in the dissecting room. The tendon was incorporated along the valve annulus. Surgery consisted of mitral valve annuloplasty performed with an undersized and a complete tendon.

Results: On gross handling PM tissue was morphologically resilient. Preparation and use of PM for annuloplasty were feasible. Anatomical reconstruction of the annulus with autogenous tissue using this tendon also was feasible. The annulus behaved as a flexible ring that allowed for improved atrioventricular continuity. Complete (n = 7) and partial (n = 7) annuloplasty rings were constructed. Metric dimensions were similar to those of prosthetic rings.

Conclusion: PM is a suitable novel autogenous tissue that can be harvested together with the radial artery and has direct relevance in ischemic mitral valve regurgitation. These tendons can be easily utilized to achieve results similar to those of pericardial reconstruction and prosthetic annuloplasty rings. The tissue is readily available from the patient, and no extra cost is incurred. Further chemical studies in the human subjects are warranted.

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INTRODUCTION

Autogenous tissue such as pericardium and fascia lata has been considered a suitable tissue alternative in reconstruction of the annulus of heart valves [Ionescu 1970]. Given the benefits of valve repair compared with valve replacement for mitral regurgitation, every patient should be considered for possible mitral valve repair [Enriquez-Sarano 1995]. However, according to the literature, tendon transfer for repair of heart valves has not been done or reported in cardiac surgery, yet the procedure is used frequently in other musculoskeletal specialties, including plastic, eye, and hand surgery [Brand 1961, Lam 1998].

Why Consider the Tendon in Mitral Valve Surgery?

Mitral valve repair techniques have stood the test of time. Given the lack of biological mass in the fascia lata and pericardium, we thought of using a tendon already well known in the field of hand surgery—the palmaris tendon—in reconstruction of the atrioventricular annulus in the mitral position. In an experimental study conducted in the anatomy laboratory, we developed the concept of atrioventricular annulus reconstruction using palmaris tendon.

The Palmaris Tendon

The palmaris longus is a slender, fusiform muscle lying on the medial side of the flexor carpi radialis muscle (Figure 1). The palmaris longus arises from the medial epicondyle of the humerus by the common tendon, from the intermuscular septa between it and the adjacent muscles, and from the antibrachial fascia. The palmaris longus ends in a slender, flattened tendon, which passes over the upper part of the transverse carpal ligament. The insertion is the central part of the transverse carpal ligament and lower part of the palmar aponeurosis. The muscle frequently sends a tendinous slip to the short muscles of the thumb. The palmaris longus muscle is often absent (approximately 10% of the time) and is subject to many variations. It may be tendinous above and muscular below; it may be muscular in the center with a tendon above and below; it may present 2 muscular bundles with a central tendon; or it may consist solely of a tendinous band. The muscle may be morphologically double. Slips of origin from

the coronoid process or from the radius have been seen. Partial or complete insertion into the fascia of the forearm, into the tendon of the flexor carpi ulnaris muscle and pisiform bone, into the navicular, and into the muscles of the little finger have been observed [Gray 1918].

Current Surgical Applications of Palmaris Tendon

The presence of the palmaris longus is confirmed by clinical examination. This muscle is often considered the ideal donor for replacement of the long flexors of the fingers and for replacement of the flexor pollicis longus tendon. Removal of the palmaris tendon causes no permanent functional sequelae [McCarthy 1990].

The palmaris longus tendon is composed of dense and regularly arranged connective tissue, giving it more tensile strength than the same portion of fascia, which is dense but irregularly arranged [Dickson 1986]. Palmaris longus tendon is sufficiently strong, tough, and wide to allow splitting it into 2 or more strips to provide more length and excursion when needed. The estimated mean tensile strength is 10 MPa [Schechtman 2002]. The tendon is composed of outer epitendon and endotendineum cells. The epitendon cells migrate into the wound and initiate the repair process with phagocytosis [Gelberman 1985]. Collagen synthesis is a function of the endotendineum cells. Tendon grafts are avascular and initially derive their nutrition by diffusion. Hence, when grafts are bathed in oxygenated blood in the left atrium, optimum nutrition will be achieved. Strong clinical evidence from animal data emphasizes “secondary” revascularization in tendon grafts. Revascularization occurs by ingrowth of capillaries and the establishment of a new vascular network [Gray 1918].

MATERIALS AND METHODS

Seven cadaveric upper extremity limbs and 2 cadaveric hearts were obtained for research purposes from male donors who had died of noncardiac causes. The palmaris tendons were used to reconstruct the mitral valve annulus either partially (posterior annulus or intertrigone) or completely. Interrupted nonabsorbable suture material was used to transfix the harvested tendon in an onlay fashion with or without pledgets. This work was done in the anatomical laboratory.

We recommend that cardiac surgeons work with hand surgeons to learn how to harvest the palmaris longus tendon safely and effectively without injury to the median nerve.

This technique may be combined with harvesting of the radial artery, typically in the context of ischemic heart disease associated with functional ischemic mitral valve disease. We recommend harvesting the tendon first if indicated because it is superficial. A transverse incision 1 to 2 cm long in the wrist crease is made over the palmaris tendon. The incision can be extended laterally for identification of the radial artery or through a separate transverse incision. This step can be done with 2 separate longitudinal incisions or through 1 incision. The skin is incised, and a combination of blunt and sharp dissection reveals the tendon lying below the deep fascia. Dissection is extended proximally to deliver all available tendon in this direction. If positive identification is assured, the ten-

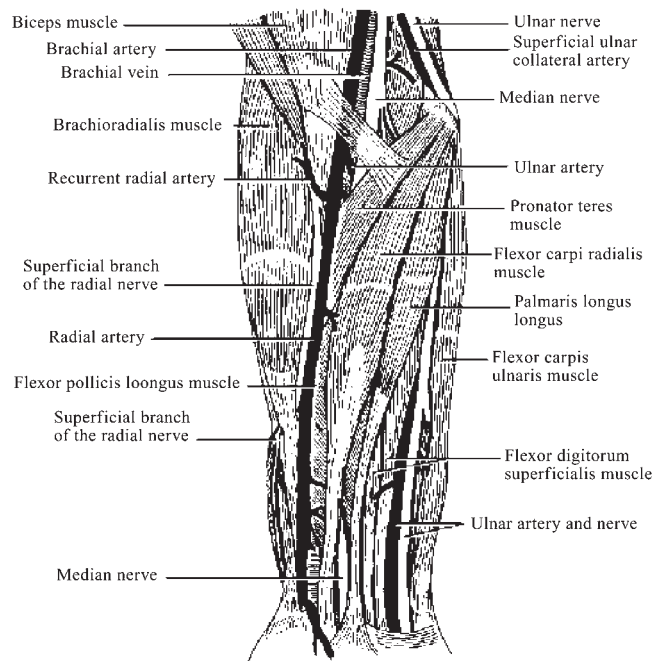


Figure 1. The anatomical relationship of the palmaris tendon to the radial artery. (Permission obtained from bartebly.com, Gray’s Anatomy.)

don is divided just distal to a hemostat clamp. Further traction on the instrument allows exposure of the proximal part of the palmaris longus tendon. Further interrupted incisions can be performed for proximal harvesting of the tendon. The incision can be made with skin retractors for harvesting together with the radial artery [Dietl 1995]. The area of dissection is closed in layers and wrapped with a dressing. Ideally when the arm is used, all immediately postoperative symptoms are localized to the same area of the body. Figure 2 illustrates freely cut palmaris tendons.

Findings in recent large series suggest that the most common repair technique (up to 98% of cases) for ischemic



Figure 2. Photograph shows sample of palmaris tendon harvested in lengths of 8 cm (top) and 5 cm (bottom).

Table 1. Palmaris Tendon Metric Dimensions Are within Those Reported for Prosthetic Rings

Variable	Palmaris Tendon Ring	Prosthetic Rings
Mean thickness, mm (n = 6)	2.3	1-2
Mean width, mm	3.5	1-2
Mean (animal) tensile strength	10 MPa	Not recorded

mitral valve disease was mitral annuloplasty [Gillinov 2001]. The advantages of mitral valve repair compared with valve replacement include avoidance of long-term anticoagulation, of suboptimal hemodynamics, and of the infectious complications of prosthetic ring annuloplasty. The tendon theoretically is stronger than strips of pericardium when loss of valve tissue occurs in severe endocarditis. In addition, the mitral valve apparatus is important in maintaining normal left ventricular geometry [Frater 1983].

RESULTS

The gross morphology and texture of harvested palmaris tendon reconfirm its resilience and flexibility as demonstrated in hand surgery. Table 1 shows the metric dimensions of the tendon compared with those of commercially available flexible annuloplasty rings. Width and thickness were within the metric dimensions of current prosthetic rings. The tendon was easy to handle and was flexible.

Seven repairs with posterior annuloplasty bands (Figure 3) and 7 complete atrioventricular rings (Figure 4) with palmaris tendon were successfully performed. Both repairs were feasible and reproducible with no difficulty. Mean tendon lengths were 8 cm and 5 cm for complete ring and partial annuloplasty reconstruction, respectively. The values are shown in Table 2. Of interest and as determined from animal data, the palmaris tendon has an estimated mean tensile strength of 10 MPa

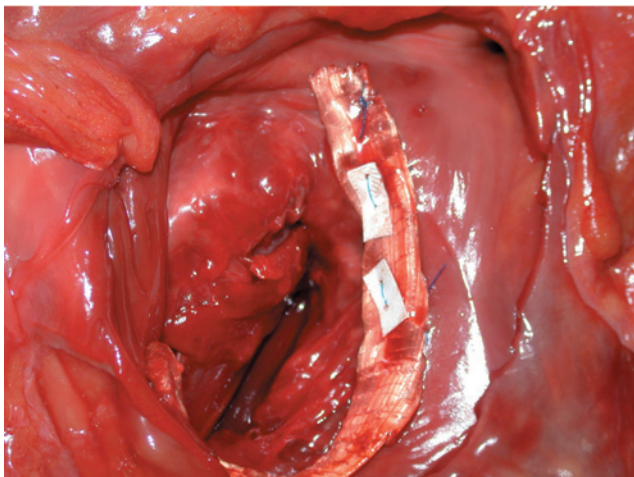


Figure 3. Feasibility of posterior annular reconstruction using palmaris tendon transfixed with either simple or pledgeted U-shaped polypropylene (Prolene) stitches. The palmaris tendon was placed on the posterior annulus.

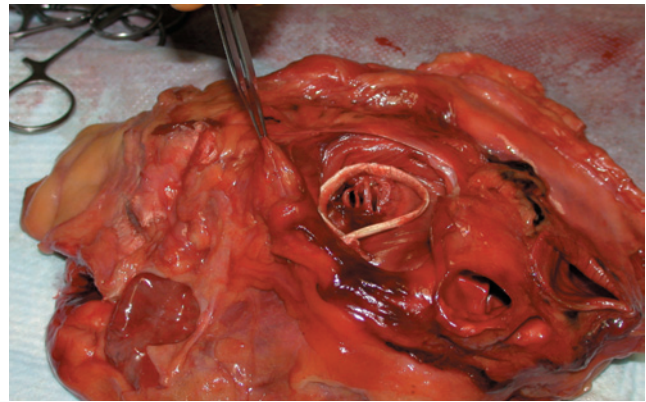


Figure 4. Feasibility of complete left atrioventricular annular reconstruction using palmaris tendon.

[Schechtman 2002]. No data were available from the manufacturers regarding the tensile strength of flexible prosthetic rings.

DISCUSSION

Repair options involve 1 or more of the 4 parts of the mitral valve and range from partial to complete repair. It recently has become important to be aware that the long-term outcome of mitral valve repair is disease dependent [Enriquez-Sarano 2003]. Of all the techniques described, annular reconstruction has an important role for both ischemic and nonischemic mitral regurgitation [Deloche 1990].

The importance of annuloplasty rings includes correcting dilatation of the annulus, increasing leaflet coaptation by restoring the valve elliptical shape, reinforcing annular sutures when part of the leaflet is resected, and preventing future annular dilation [Chachques 1990]. Modalities of annular repair include use of an annuloplasty ring prosthesis (flexible or rigid, band or complete ring) [Ionescu 1970], use of autogenous annuloplasty rings made with fascia lata, pericardial reconstruction of the annulus with or without glutaraldehyde treatment, and use of absorbable bioprosthetic rings.

Limitations for use of currently available prosthetic annular rings include the presence of active bacterial endocarditis, reluctance to place the rings in children due to risk of secondary valvular stenosis, presence of fibroblastic pannus growth, and presence of heavily calcified valve with reduced mobility. Therefore, autogenous tissue remains essential when prosthesis is contraindicated.

Annuloplasty and Valve Repair with Palmaris Tendon

Several advantages exist in repair rather than replacement of a mitral valve when feasible. Maintaining atrioventricular

Table 2. Feasibility, Number, and Length of Repairs

Palmaris Ring	Feasible	Number	Mean Tendon Length
Complete annular ring	Yes	5	8 cm
Partial posterior annuloplasty	Yes	2	5 cm

continuity, avoidance of anticoagulation, and avoidance of the potential for endocarditis are well-known bonuses of repair of the mitral valve.

Development of this novel concept shows that such repair is feasible and potentially durable, given the good to excellent long-term results in hand surgery. Tendon tissue is useful for annuloplasty because of its tissue bulk and smooth outer surface. Moreover, the wide availability of palmaris tendon makes it an inexpensive source of biological tissue for reconstructing atrioventricular annuli. In the context of operative annulus decalcification, the tendon can fill in for the majority of bulk tissue loss.

The fascicles of the palmaris tendon (and the fibrils) can move to some extent separately from their neighbors. Examination of the tendon in this study suggested that mechanical strength was achieved by preserving the integrity of the tendon as a discrete cable in which epitenon adventitia contained all fibrils. The use of this tendon should be encouraged and extended to procedures involving other areas of the heart, including aortic annulus repair and tricuspid annuloplasty.

Conclusion

Healthy and durable autologous tissue is biologically superior to artificial tissue. Preliminary animal and human studies need to be performed in the near future to delineate the role of palmaris tendon grafts in modern valve surgery. Palmaris tendon can be harvested either percutaneously or by open technique. When the tendon is harvested in the open fashion, the radial artery can be harvested with the tendon. Harvesting of the tendon with the radial artery is easily performed when radial artery is needed for treatment of ischemic mitral valve disease.

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