AUTOGENOUS BIOLOGICAL POLYMERS IN RETINAL DETACHMENT SURGERY*

I. THE PLANTARIS FUSIL

BY

G. W. CROCK† AND J. E. K. GALBRAITH‡

Department of Ophthalmology, Melbourne University, Australia

THE place of the encircling operation has already been firmly established by Schepens and other workers, although there is no uniformity of opinion as to the precise indications for this procedure. Some of the risks inherent in encirclement have been due to the properties of the foreign implant material (Boniuk and Zimmerman, 1961; Regan and Schepens, 1962; Kornblueth, Behar, and Zauberman, 1964; Kurz and Ezrow, 1965; Lincoff, 1960). New plastics have been developed (Schepens, Okamura, Brockhurst, and Regan, 1960; Everett and Sharrer, 1961; Girard and McPherson, 1962; Regan, Schepens, Okamura, Brockhurst, and McMeel, 1962; Breslin, 1963; Lincoff, Baras, and McLean, 1965), and several different tissues have been utilized (Dellaporta, 1962; Johnson, Henderson, Parkhill, and Grindlay, 1962; Havener and Olson, 1962; Klöti, 1964; Havener and Wachtel, 1964; Scott, 1964; Wilson, 1964) in an effort to overcome these problems.

This paper describes the method of construction of an autogenous graft fashioned in the form of a fusil§ from the plantaris tendon, for use as an encircling element in retinal detachment surgery. The properties of the tendon which will be described below permit the manufacture of an implant that is an integral part of the encircling component.

Autogenous grafts were first employed at the Melbourne University Department of Ophthalmology in cases referred after failure of scleral resection with potassium hydroxide cauterization, or after diathermy applications through whole sclera. Use of foreign material was considered technically impossible or undesirable in these circumstances. Satisfactory results were achieved with autogenous tendon and fascia, and access was so rapid and easy to these tissues, that over the past 18 months the use of this technique has been extended to primary operations. High buckles produced by autogenous implants have now been observed to persist for this period.

A statistical analysis of the 150 cases so far treated with this technique will be undertaken in a subsequent communication. Modifications to the technique required in special cases and problems of re-operation will also be reported later.

* Received for publication October 28, 1965.

† Ringland Anderson Professor of Ophthalmology, Royal Victorian Eye and Ear Hospital, Melbourne.
Director of the Ophthalmic Research Institute of Australia.

‡ First Assistant in the Department of Ophthalmology.

§ The word fusil is derived from the old French *fuisse* and from the Latin *fusus*—a spindle. In the present context the term denotes a spindle-shaped expansion produced in the plantaris tendon.

The general requirements of autogenous material for grafting are as follows:

- (1) Suitable structure, shape, and quantity.
- (2) Simple, rapid removal.
- (3) No resultant functional defect at donor site.
- (4) Maintenance of form in recipient site.

Before the plantaris fusil was first constructed for use, the following autogenous tissues were investigated:

(1) *Fascia lata*.—This fulfils the required criteria provided that it is autogenous, as preserved homogenous grafts may fail to survive (Peer, 1955; Burdick, Gillespie, and Higinbotham, 1937).

(2) *Achilles tendon*.—Sufficient length is somewhat difficult to obtain and like fascia lata it tends to shred. Post-operative pain in the calf is a further contraindication to its use.

(3) *Extensor tendons from the foot*.—These fail to satisfy the criteria because only short lengths can be obtained.

(4) *Palmaris longus*.—This is an admirable tendon, but it is absent in 14 per cent. of cases compared with 7 per cent. for plantaris, and it is only half as long. In our opinion, this is the second choice because it has the same properties as plantaris and, moreover, can be recognized pre-operatively.

(5) *Plantaris*.—This is considered to be the ideal tendon as it fulfils all the criteria.

Surgical use of this tendon was first described by Glissan (1932), and it has been widely used in plastic surgery since then.

Anatomy of Plantaris Muscle.—In man this muscle is a vestigial structure, taking origin from the posterior aspect of the lower end of the femur, and inserting into the calcaneus. It arises from the distal portion of the linea aspera and the posterior ligament of the capsule of the knee joint, closely related to the lateral head of the gastrocnemius.

The belly, usually 8–10 cm. long, may vary from a fibrous structure to a well-developed spindle-shaped muscle equal in size to the lateral head of the gastrocnemius. The origin shows many variations, and is sometimes bicipital. The muscle lies lateral to the popliteal vessels and the tibial nerve, postero-medial to the lateral head of the gastrocnemius. It gives rise to a tendon which is about 45 cm. long, 4 mm. wide, and less than 1 mm. thick.

The tendon passes distally between the soleus and gastrocnemius in the avascular space, lying in loose areolar tissue, to reach the antero-medial aspect of the Achilles tendon.

The plantaris tendon inserts into the calcaneus. Daseler and Anson (1943) recorded the form and position of this insertion in 150 legs, and classified them into four types which may be summarized as follows:

(I) Found in 48 per cent.—The tendon inserts by a short fan-shaped expansion into the medial extremity of the superior tuberosity for insertion of the Achilles tendon.

(II) Found in 32 per cent.—The tendon inserts into the calcaneus 0.5 cm. to 2.5 cm. anterior to the Achilles tendon, the long axis of the insertion being usually at an angle to the long axis of the foot.

(III) Found in 15 per cent.—The tendon is usually broad and invests the dorsal and medial surfaces of the Achilles tendon, inserting into the calcaneus lower down than Type I or II.

(IV) Found in 5 per cent.—The tendon inserts into the medial border of the Achilles tendon from 1–16 cm. above its insertion into the calcaneus. Occasionally a slip of plantaris tendon reaches down to the bone.

Agensis.—The plantaris tendon may be absent. White (1960a) quotes an aggregate of several studies, in which 2,650 legs were examined and 187 instances of agensis were found (7.05 per cent.). Daseler and Anson (1943) quote an incidence of agensis of 8.2 per cent. in males and of 5.8 per cent. in females, more commonly on the left side. They found that in cases in which the tendon was absent, it was bilaterally absent in one-third. If it was poorly developed on one side, they stated that it was likely to be so also on the other.

Cumulative results in similar studies of palmaris longus revealed absence in 580 (14.3 per cent.) of 4,040 specimens (White, 1960b).

Removal of Plantaris Tendon.—This may be performed by an assistant surgeon with the patient in the supine position, while the sclera is being exposed.

A 5 cm. vertical incision is made over the medial aspect of the right Achilles tendon, 2.5 cm. above its insertion into the calcaneus, so avoiding any difficulties due to variations in tendon insertion. The incision is deepened and the plantaris tendon will then be found as a slender strand, lying antero-medial, medial, or postero-medial to the Achilles tendon, and it may be drawn downward without associated movement of the larger tendon. If the plantaris is absent on the right side, it should always be sought on the left.

The plantaris tendon is divided near its insertion and threaded through the loop of a Brand tendon stripper, the free end being grasped with two haemostats while steady pressure is exerted on the tendon as the stripper is forced up the leg. If the tendon is angulated, it may be severed prematurely a few inches above its insertion.

During this procedure the knee must be held extended. The instrument passes readily until it reaches the belly of the plantaris muscle, when resistance will be encountered. At this stage, and not before, rotary movement of the handle of the stripper is made to sever the muscle and so release the tendon.

The muscle belly lies in close relationship to the neuro-vascular bundle in the popliteal space. When the stripper reaches this level, its tubular opening is filled with muscle which prevents the sharpened edge from damaging the major nerves or vessels and these are further safeguarded by the knee extension.

After closure of the skin incision, a dressing is applied, and crepe bandaging is continued up to the lower thigh to be left undisturbed until the stitches are removed from the ankle on the seventh day. Walking may start on the day following operation. Leg pain is usually slight, lasting only a few days.

Properties of Plantaris Tendon.—This is the longest tendon in man. It is surrounded by a well-developed paratenon which is usually removed with the tendon. The most unusual feature of the plantaris tendon is its ability to be stretched laterally. If the edges are grasped with forceps, they may be drawn apart as much as 5 cm. pulling the tendon out into a thin sheet of unbroken fibrous tissue (Pilcher, 1939). This lateral stretching occurs at the expense of length, but longitudinal traction on the ends of the tendon will reconstitute its original shape. This facility is employed in the construction of the plantaris fusil. The only other tendon to share this property is the palmaris longus.

Manufacture of Fusil

The plantaris fusil is a spindle-shaped enlargement produced by enclosing lengths of tendon within the plantaris tendon itself.

The tendon is laid out on a glass plate, paratenon is stripped off with forceps (Fig. 1), and the muscle is removed. In its central third, the edges of the tendon are grasped at opposite points by plain forceps, which are drawn apart for about 2.5 cm., causing the tendon to become diamond-shaped here. The two outstretched points are pressed onto the glass and adhere to it.

FIG. 1.—Removal of paratenon from plantaris tendon.

FIG. 2.—Thin sheet of plantaris produced by lateral stretching of tendon.

The stretching manoeuvre is repeated every few millimetres along the tendon, until a thin sheet has been formed, 2.5 cm. broad and slightly longer than the scleral trapdoor (Fig. 2). This local widening of the tendon has been produced at the expense of thickness and over-all length. Pieces of tendon of the same length as the scleral trapdoor are now cut from each end of the plantaris and are laid side by side along the sheet (Fig. 3). Each is anchored to the sheet at one end with 5/0 plain catgut. The number of pieces used depends upon the width of the trapdoor—three is the usual number.

FIG. 3.—Pieces of tendon laid side by side along tendon sheet to form a fusil.

FIG. 4.—The plantaris fusil. Sufficient tendon remains on each side of the fusil to encircle the globe.

The free edges of the outstretched tendon are sutured together over these pieces with a 5/0 plain catgut continuous suture. Tethering the enclosed strips of tendon has prevented them from sliding out of position at this stage. A flaccid widening has now been produced within the central third of the plantaris tendon. This is converted into a firm fusil by pulling on the free tendon ends, and then the suture is knotted. While the fusil is held under tension, two catgut sutures are knotted tightly around it, one at each end (Fig. 4). Sufficient tendon remains on each side of the fusil to allow the globe to be encircled and the tendon to be knotted. The total requirement for an average fusil is 20 cm. of tendon. Investigations undertaken for us by O. Delatycki of the Faculty of Applied Science in the Melbourne University, with the help of the Commonwealth Scientific and Industrial Organization, have demonstrated that the tensile strength of the plantaris tendon is not decreased by the presence of a fusil within it.

Technique in Primary Operations

The operation follows Schepens's technique with the modification that the fusil is used in place of silicone rubber (Figs 5 and 6). Attention is drawn to the method of fixation of the free ends of tendon. Because of its high tensile strength and low elasticity, great care must be exercised in tightening the tendon once it has been threaded around the globe beneath the extra-ocular muscles. The free ends are united by a double throw single knot which is lightly strained by an assistant while the central retinal vessels are inspected for patency. The extremities of the knot are finally transfixed with sutures (Fig. 7).

FIG. 5.—Fusil tailored to fit scleral trapdoor.

FIG. 6.—Scleral trapdoor closed over fusil.

FIG. 7.—Tendon knot with transfixing sutures.

Where necessary, the tendon may be tethered to the globe between the rectus muscles by a mattress suture, though the scleral tunnel method of Klöti (1965) and other workers is to be preferred.

Before the development of the plantaris fusil, various methods were used to produce an adequate choroido-retinal buckle. These included multiple strips of plantaris tendon placed separately around the globe, or a single length of tendon looped more than once around the eye. In the former method accurate placement of individual strips was time-consuming, while in the latter it was found difficult to effect uniform tension in all loops.

Discussion

Peer (1955), has stressed the value of autogenous agents:

It is important always to bear in mind that there is not a single instance where an autograft is not superior to a homograft as grafting material. When a homograft is used clinically, there should always be a definite reason why an autograft could not be utilized. At the present time, there are no exceptions to this statementWhen autogenous grafts are used, the host reaction is less intense, healing is more rapid and in all of the commonly used grafts, excepting nerve, muscle and dense cellular bone, the cellular elements in the graft tend to survive transplantation as living cells.

This is particularly true in the eye where the complications of homografts and synthetic materials (late rejection, infection, and erosion) can be catastrophic.

At first the techniques utilizing plantaris tendon were clumsy and time-consuming, but appreciation of its unique properties has led to the development of the fusil; this has greatly simplified detachment surgery because the fusil combines in a single unit the functions of a grooved silicone implant and encircling strip, producing a buckle comparable to that made by silicone implants.

Summary

The anatomy, characteristics, and technique of removal of the plantaris tendon have been described.

The plantaris fusil utilizes an autogenous biological polymer in place of silicone. Its application to the surgery of retinal detachment follows established principles.

The fusil combines in a single unit the functions of a grooved component and an encircling strip.

The buckles produced by the plantaris fusil are permanent. This tissue suffers from none of the long-term complications of plastic materials, or heterogenous or homogenous grafts, such as erosion, rejection, and absorption.

Grateful acknowledgement is made to the specialists who kindly referred their cases for treatment, Miss B. Clifton and Miss P. Adams for secretarial help, Miss I. Hill for the drawings, Mr. D. W. Charles for technical assistance, and the theatre staff of the Royal Victorian Eye and Ear Hospital, Melbourne.

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