Oct. 19, 1971 G. B. McFARLAND, JR 3,613,120

FLEXOR TENDON PROSTHESIS

Filed Oct. 21, 1969

FIG. 1

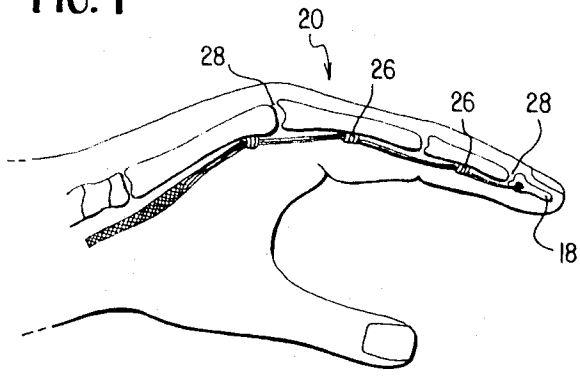


FIG. 2

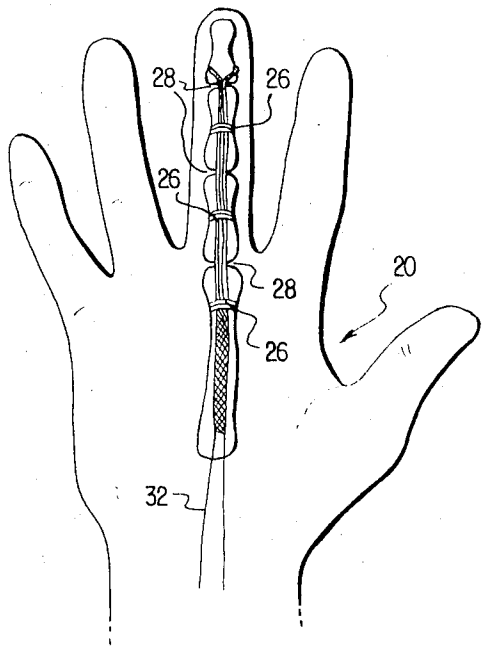
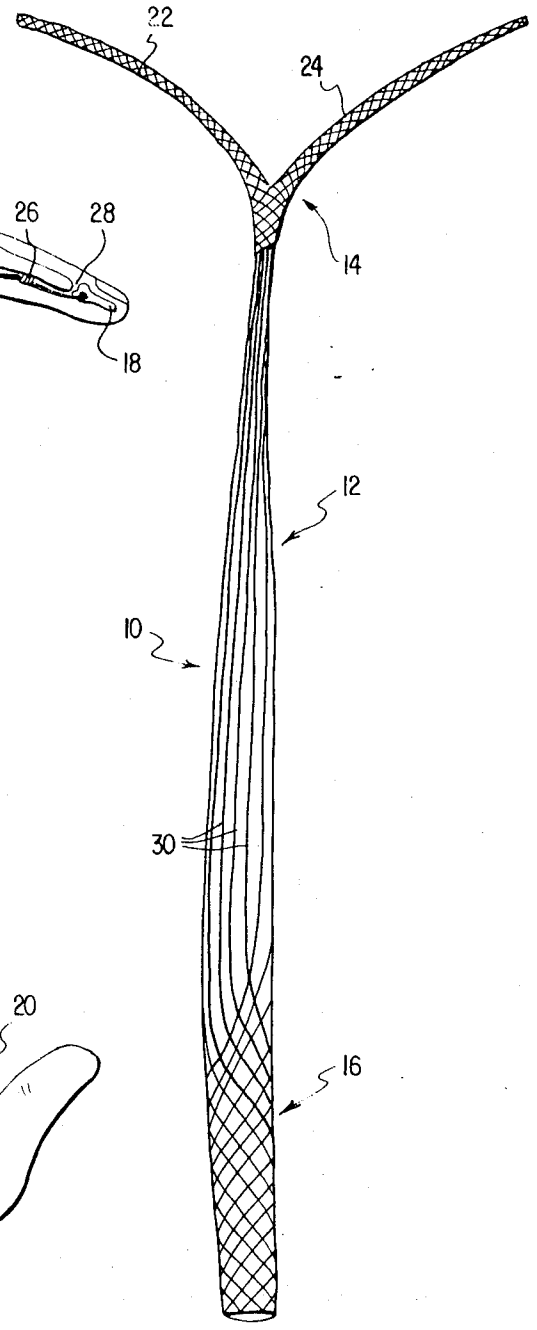


FIG. 3



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FLEXOR TENDON PROSTHESIS

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ABSTRACT OF THE DISCLOSURE

Artificial tendons, and particularly a prosthesis for flexor tendons, are provided which comprise end portions which are woven, or of other open mesh configuration to promote ingrowths of fibrovascular tissue essential for good tendon anchorage and a center portion consisting of multiple parallel filaments which resist infiltration of fibrovascular tissue and promotes free sliding motion of the center part of the prosthesis.

Successful surgical repair particularly of the flexor tendons after injury within the digital tendon sheaths is difficult to achieve, both because the blood supply to these parts of the tendons comes in primarily from the ends of the sheaths and because re-creation of the sliding mechanism provided by the synovial membrane between the two sets of tendons and between them and their surroundings has proved substantially impossible. In view of these and other difficulties these parts of the tendons have been termed the "no man's land" of tendon surgery.

At the present, management of lacerations of flexor tendons between the distal crease of the palmar and the flexion crease of the proximal interphalangeal joints or (no man's land) is a flexor tendon autograft obtained from the plantaris of palmaris longus tendon of the patient. These grafts are inserted by well worked out techniques being attached at the base of the distal phalanx at the ordinary insertion of the flexor profundus and proximally into the flexor profundus tendon just distal to the origin of the lumbrical muscle passing through the naturally occurring pulleys in the finger.

The naturally occurring pulleys are formed primarily by the digital tendon sheaths on the fingers. These sheaths consist of a rather heavy outer fibrous portion and an inner synovial portion; the fibrous portion is in all cases confined to the digit. The outer fibrous wall of each digital sheath consists of alternating thin and thick portions; in front of the metacarpophalangeal and each interphalangeal joint fibers run obliquely to form the thin cruciform part of the sheath, while over the bodies of the proximal and middle phalanges heavier fibers run transversely to form the annular part of the sheath. The transverse fibers serve as retinacula that keep the long flexor tendons in close contact with the bones; the proximal set, particularly strong, is frequently referred to by clinicians as the pulley of the flexor tendons.

The above-described technique, while workable, has many difficulties. It has been shown that flexor tendon grafts obtain their blood supply by ingrowth of fibrovascular tissue from the surrounding tissue in the finger. Without this ingrowth the graft does not become incorporated and regenerated as tendon. While these ingrowths of fibrovascular tissue are essential for survival of the graft they also provide the basis for the rehabilitation problems associated with grafting. As these fibrovascular granulations grow into the tendon they anchor the tendon so that it loses excursion. These adhesions must be stretched out to obtain the excursion necessary for complete function of the finger. Sometimes these adhesions are so dense that no motion occurs, and the hand must be re-explored with lysis of the adhesions and the rehabilitation process starts all over.

It has also been shown that a tendon anastomosis at three weeks has only 12% of the tensile strength of normal tendon. This is the customary time for removing external splinting in a tendon graft, and it requires four months for normal tensile strength to develop. This is an unacceptably prolonged period before a working man can return to gainful employment. It is for this reason, with the high number of industrial injuries involving flexor tendons, that work has been carried on throughout the country for many years on a substitute for the flexor tendon graft. The methods used have been Silastic rods with embedded wire cable, Silastic rods with embedded Dacron or Teflon tape, large suture material and the like.

It is an object of the present invention to provide an improved artificial tendon and particularly an improved prosthesis for a flexor tendon which:

(1) utilizes already well worked out and accepted surgical methods of management and technique,
(2) is immediately usable with high tensile strength,
(3) has high acceptability in human tissue,
(4) is relatively free from binding adhesions, and
(5) has ultimate invasion by normal fibrous tissue to the point that clinically and functionally it would be living and nearly identical with a normal tendon.

These and other objects and advantages are provided by a tendon prosthesis comprising a central section and integrally joined end sections, each of said end sections consisting of open mesh plastic material adapted to be receptive to ingrowth of fibrovascular tissue for anchoring of the end sections of the tendon and said central section including at least one high-strength plastic fiber or filament not subject to fibrovascular tissue ingrowths.

The invention will be more particularly described in reference to the accompanying drawing wherein:

FIG. 1 is a diagrammatic side view of a human hand showing certain bones of a finger and the improved flexor tendon of the invention;

FIG. 2 is a front or palmar view of the hand shown in FIG. 1; and

FIG. 3 is an enlarged view of the improved flexor tendon of the invention.

Referring to the drawing and in particular FIGS. 1 through 3, **10** generally designates the improved prosthesis which generally consists of a central section **12** and end sections **14** and **16**. Since the illustrated prosthesis is primarily intended as a replacement for the flexor tendon the distal end **14**, which would have a bony insertion into the distal phalanx **18** of the hand **20**, is a two-tailed, as at **22** and **24**, woven or knitted fabric which would allow ingrowth of fibrovascular buds and dense scarring to occur causing a tight insertion. The mid portion **12** of the prosthesis **10**, which must pass through the pulleys **26** and across joints **28** would be composed of continuous and parallel or nearly parallel fibers **30** of Dacron or Teflon which even if ingrowth of fibrovascular buds did occur would allow relative motion between the tendon and the tissue since there would be no cross fibers to catch on the fibrovascular buds. In general it has been found that the center section should contain at least 4 to 6 filaments and preferably 10 to 50 filaments.

The proximal end **16** again would be relatively tightly woven for anastomosis with the tendon. This would allow scarring again to occur at the anastomosis for a tight physiologic attachment to the tendon. Ultimately enough ingrowth of fibrous tissue will occur from the two ends to completely infiltrate the parallel fibers **30** of the prosthesis without the concommitant adhesions to the pulleys **26** and surrounding tissue. Thus, early motion is accomplished, and high tensile strength would be maintained throughout the life of the patient, ultimate infiltration by normal fibrous tissue would be expected to occur

and the insertion of the prosthesis would be utilizing already existing techniques. Suitable generally in-elastic synthetic plastic materials for the prosthesis, in addition to Dacron and Teflon, include Kel–F (polyfluorotrichloroethylene), Silastic, Silastic coated fibers and other fluoroplastics.

In the preferred embodiment of the invention, the end sections **14** and **16** may be woven, knitted or braided; the weaving, knitting or braiding may be of the tubular type and the number of filaments forming the open mesh end sections may be the same or different than the number of parallel fibers forming the center section **12**. Further, the gauge or denier of the filaments of the end sections may be the same or different from those forming the center section and the number of filaments and their denier may be the same or different at the two ends.

While woven, knitted or braided end sections are preferred it will be appreciated that the open mesh end sections may be formed from hollow tubular stock material that has been perforated to permit the necessary ingrowth of fibrovascular tissues.

The lengths and diameters of the end sections and the center section of the prosthetic tendon may be of any desired lengths and diameters depending upon the particular uses and functions of the finished product. Further, the cross-sectional configuration of the center section and the end sections may be circular, oval or elliptical or relatively flat; however, in general, the artificial tendon should be so constructed, as to conform to the cross-sectional configuration and the size of the original tendon. Likewise, the length of the parallel filamentary center section and the length of the end section **14** should, in general follow the dimension of the natural tendon to be replaced while the length of the end section **16** would be long enough to permit the end to receive the end of the natural tendon segment **32** that is to be inserted within the end **16** to permit a zone of tissue ingrowth to provide a suitable bond between the natural and the synthetic tendon.

While preferred embodiments of the invention have been shown and described, many variations and modifications therein may be made in the structures of the defined invention.

I claim:

1. A tendon prosthesis comprising a central section and integrally joined end sections, each of said end sections consisting of open mesh plastic material adapted to be receptive to ingrowth of fibrovascular tissue for anchoring of the ends of the tendon and said central section consisting of multiple longitudinally parallel filaments which resist infiltration of fibrovascular tissue and promotes free sliding motion of the central portion of the prosthesis.

2. The invention defined in claim **1** wherein one of said end sections is bifurcated.

3. The invention defined in claim **1** wherein the central section and the end sections comprise Teflon.

4. The invention defined in claim **1** wherein the central section and the end sections comprise Dacron.

5. The invention defined in claim **1** wherein the central section comprises a plurality of generally parallel plastic monofilaments.

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