Sept. 13, 1966 C. ARTANDI ETAL 3,272,204

ABSORBABLE COLLAGEN PROSTHETIC IMPLANT WITH NON-ABSORBABLE REINFORCING STRANDS

Original Filed March 1, 1961 2 Sheets-Sheet 1

Fig. 1.

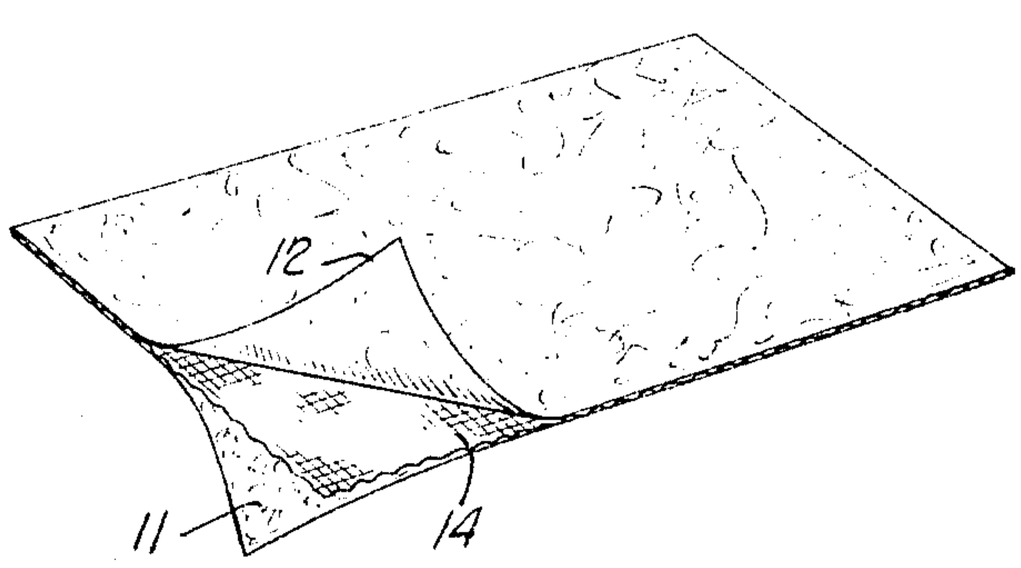

Fig. 2.

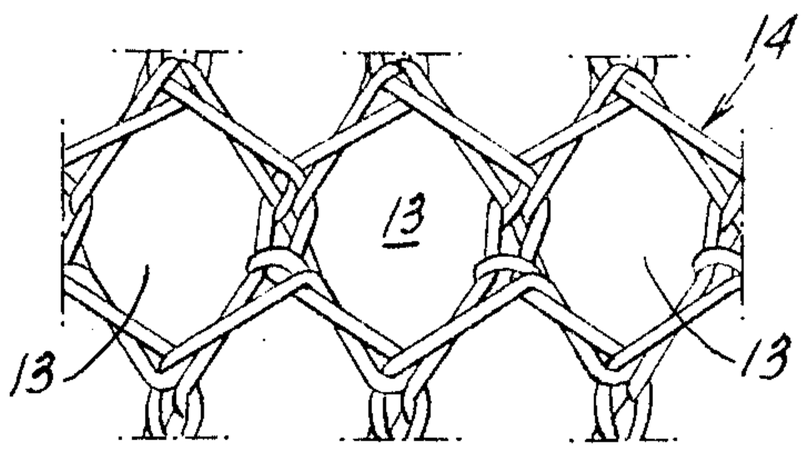

Fig. 3a.

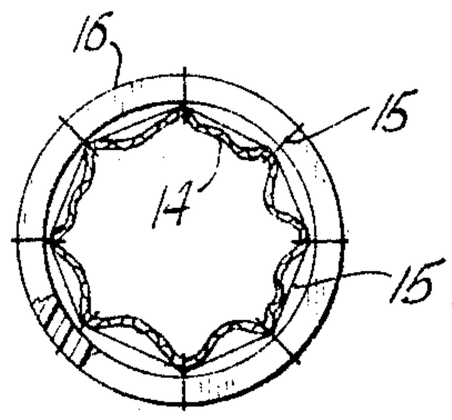

Fig. 3.

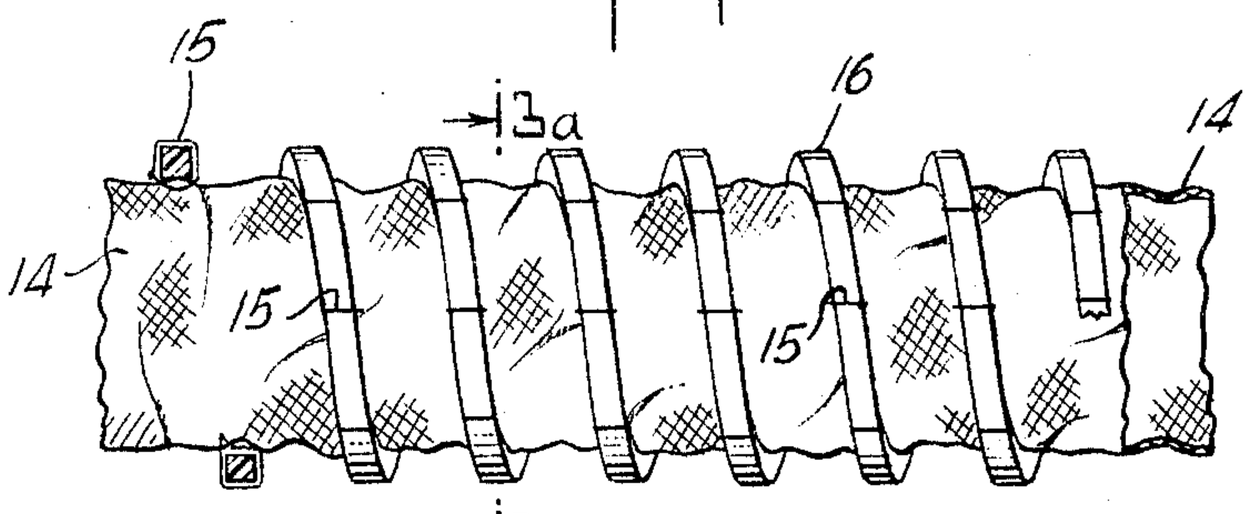

Fig. 3b.

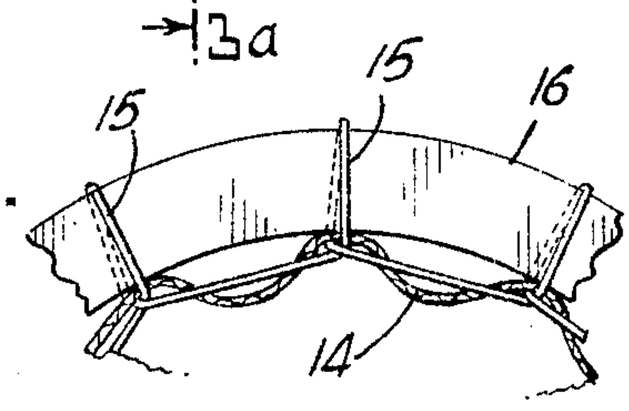

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FIG. 4.

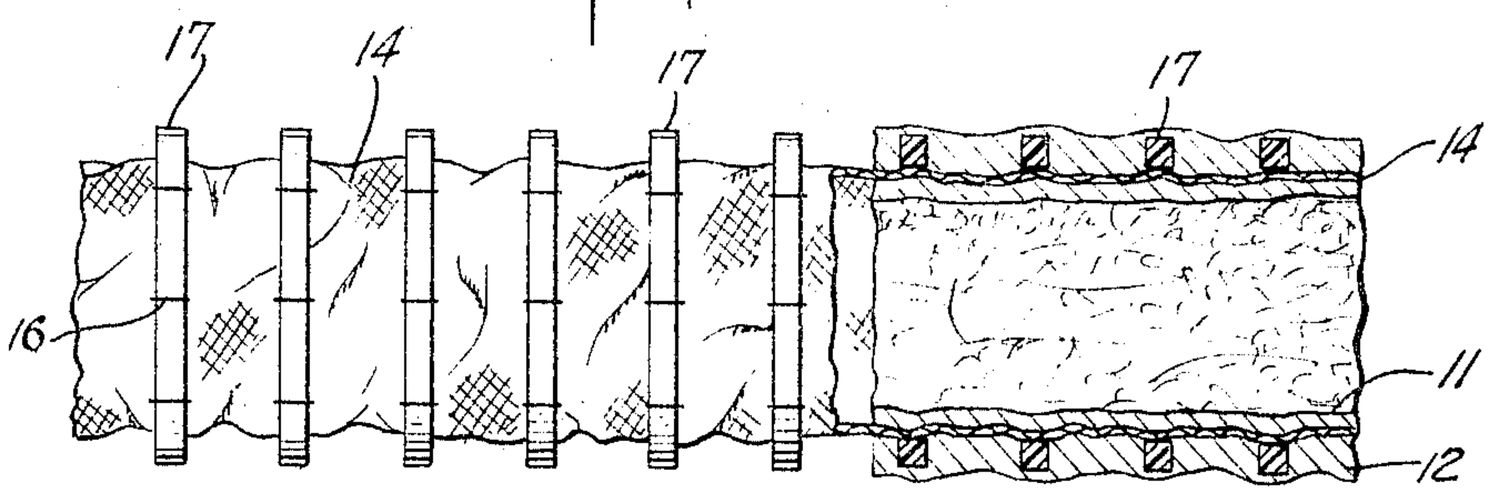
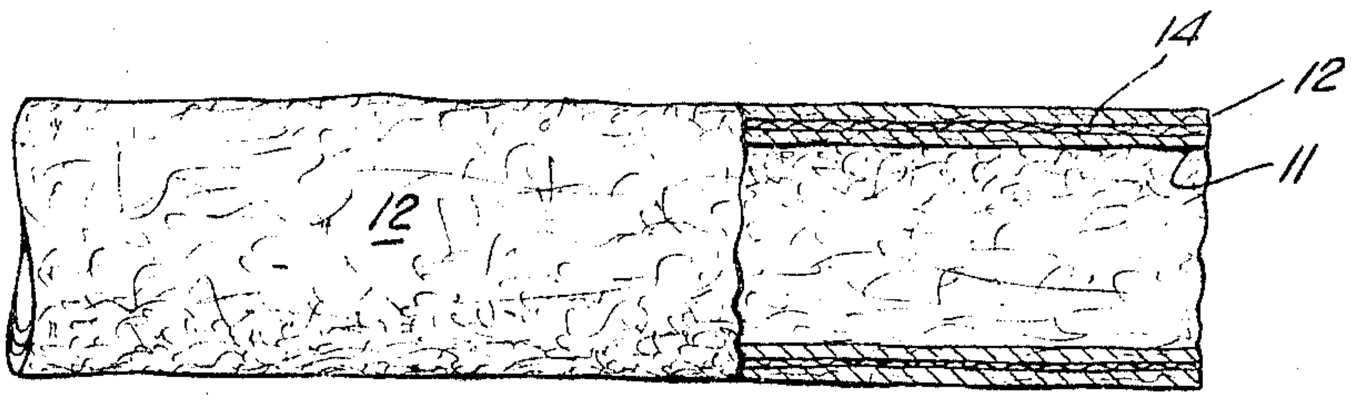


FIG. 5.



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ABSORBABLE COLLAGEN PROSTHETIC IMPLANT WITH NON-ABSORBABLE REINFORCING STRANDS

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Continuation of application Ser. No. 92,620, Mar. 1, 1961. This application Sept. 22, 1965, Ser. No. 495,010

15 Claims. (Cl. 128—334)

This application is a continuation of copending application Serial No. 92,620, filed March 1, 1961, now abandoned.

The present invention relates to reinforced collagen prostheses adapted to be placed permanently in the human body, and to a method of making the same. More particularly, this invention relates to collagen articles that are reinforced with non-absorbable fabrics.

In the surgical repair of hernias, tantalum gauze and inert fabrics have found considerable use, particularly in older patients who are recognized to have a reduced ability to rebuild tissue at the point of surgery. Tantalum gauze, however, has the undesirable property of work hardening and may curl up within the body, causing discomfort. Inert fabric prostheses have the disadvantage that they do not become a part of the body tissues. Such inserts frequently remain surrounded by a pool of sera after the healing process. A suitable prostheses for strengthening the repair should be non-toxic, flexible and porous. The ideal prostheses should retain its strength permanently in intimate contact with body fluids and should be readily accepted and incorporated into the tissue. Porosity is an important characteristic of such a prosthesis to avoid the formation of fluid pockets and to promote the growth through the fabric of repair tissue.

The present invention has for its principal object the provision of flexible films and tubes constructed of collagen and reinforced with an open mesh, non-absorbable fabric that is compatible with the human body.

A further object of the invention is the provision of such flexible tubes that are not subject to kinking or collapsing in any desired diameter or length suitable for use with human arteries or veins.

Another object is the manufacture of prostheses having a structure which promotes the growth of body tissue into and through the prostheses during the healing process.

It has now been discovered that an improved prostheses can be constructed using as a framework or support a non-absorbable plastic material, knitted, woven or braided to have a wide mesh, thus permitting easy invasion by the host into the interstices between the non-absorbable fibers. In the improved prostheses of the present invention, the interstices between the non-absorbable fibers are initially filled and rendered blood tight by collagen fibrils. The collagen fibrils have considerable tensile strength, are non-antigenic, are slowly absorbed and permit satisfactory in-growth of fibroblasts and endothelial cells, resulting in attachment of the prosthesis to the host tissues. Since collagen is the type of connective tissue normally laid down by the body during the healing process, there is no appreciable decrease in the strength of the prosthesis during the period that the collagen fibrils are being replaced.

The invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawings, showing by way of example, a preferred embodiment of the inventive idea. Referring now to the drawings:

FIGURE 1 is a view of a reinforced collagen film. In this view, the surface collagen films have been forcibly pulled away from the non-absorbable fabric to illustrate the laminated construction.

FIG. 2 is a greatly enlarged view of the non-absorbable fabric that forms the reinforcing central element of the structure illustrated by FIG. 1.

FIG. 3 is a view of a fabric mesh tube reinforced with a plastic helix.

FIG. 3*a* is a view in section of a fabric mesh tube reinformed with a plastic helix on the line 3*a*—3*a* of FIG. 3.

FIG. 3*b* is a large scale fragmentary sectional view of FIG. 3 showing a method of supporting a fabric tube in accordance with a feature of the instant invention.

FIG. 4 is a view, partially in section, of a fabric mesh tube reinforced with plastic rings and coated with collagen fibrils.

FIG. 5 is a view, partially in section, of a reinforced molded collagen tube.

The non-absorbable fabric that is used to reinforce the collagen prostheses of the present invention may be knit, woven, crocheted or braided in the desired shape of any synthetic or natural fibers that are compatible with the human body. Examples of suitable materials are Vinyon-N, a resin manufactured by the Carbide and Carbon Corporation by copolymerizing vinyl chloride and acrylonitrile; nylon, a polyamide resin made by polymerization of the hexamethylene diamine salt of adipic acid; Orlon, a synthetic fiber made by the E. I. du Pont de Nemours & Co., from polyacrylonitrile; Dacron, a synthetic fiber made by the E. I. du Pont de Nemours & Co., from terephthalic acid and ethylene glycol; Teflon, a tetrafluoroethylene polymer manufactured by the E. I. du Pont de Nemours & Co.; cotton and silk. Dacron and Teflon are particularly preferred because both have displayed excellent retention of tensile strength over long periods of time and both are essentially inert. Teflon being slightly more inert and slightly stronger than Dacron.

The non-absorbable fabrics may be knitted, crocheted, woven or braided in the shape of the desired prosthesis as a film, tube, Y-tube, etc. Optionally, a film of the fabric may be rolled or cut and sewed with suitable thread to form the desired shape. The fabric may be further strengthened by plastic rings as illustrated in FIG. 4. It is important that the mesh of the non-absorbable fabric be sufficiently open to permit the collagen fibrils to extend into and through the interstices of the fabric. These collagen fibrils that pass through the fabric cohere to the collagen fibrils on either side of the fabric framework and form a unitary structure that resists delamination.

After the fabric framework has been constructed in the desired shape, it is coated on both sides with a collagen mass obtained by swelling collagen fibrils in an aqueous acid solution. The swollen collagen fibrils are then frozen in position and deswollen by dehydration in an organic solvent.

The improved prostheses of the present invention may also be manufactured by an alternate process consisting of knitting, weaving, crocheting or braiding together an inert non-absorbable thread or yarn with collagen yarn or collagen multifilament. A suitable fabric can be woven with warp yarns of Dacron or Teflon and filling yarns of collagen. The preparation of a collagen multifilament suitable for such use is described in United States patent application Serial No. 768,969, filed October 22, 1958, abandoned in favor of continuing application Serial No. 102,533, filed April 12, 1961, now Patent No. 3,114,372.

It will be understood that the collagen present in the prostheses of the present invention may be treated with tanning agents such as formaldehyde, pyrogallol, chromium, etc., by methods well known in the art to obtain

increased strength and control the rate at which the collagen will be absorbed.

The present invention is more fully described and exemplified in the following examples. It is to be understood, however, that our invention is not to be limited to any specific form of materials or conditions set forth in the examples, but is limited solely by the description in this specification and the appended claims. Throughout the specification and the examples which follow, all quantities are expressed in parts by weight.

EXAMPLE I

The deep flexor tendon of cattle is cleaned of fat, superficial non-collagenous protein and other extraneous matter and is sliced on an electric meat-slicing machine (rotary knife) in the frozen condition. The tendon sections are sliced perpendicularly to their longitudinal axis to a thickness of about 11 mils. An aliquot sample of the tendon slices is analyzed; the dry solids amounts to 36.97%.

The sliced tendon is next treated with an enzyme solution to dissolve elastin. The enzyme solution is prepared by dissolving 0.15 part of ficin and 3.75 parts of ethylene diamine tetrasodium tetraacetate in 750 parts of water. Seventy-five parts of the sliced tendon is immersed in this solution which is stored at room temperature overnight. Then 2.25 parts of 30% hydrogen peroxide is added to destroy any residual ficin.

To this mixture of tendon slices in about 750 parts of water is added an additional 2244 parts of water and 5.87 parts of cyanoacetic acid. The swelling solution is cooled to below 25° C. This mixture is stirred in a dispersion kettle at about 60 r.p.m. The remaining steps in the process are carried out at temperatures below about 25° C. and the temperature of the collagen dispersion is not allowed to exceed this temperature.

Stirring is continued for about 3 hours, during which time the individual collagen slices are swollen. The dispersion is then homogenized by repeated passes through series-connected jets having orifices of 50 mils and 40 mils respectively. The dispersion is then forced through a leaf filter containing three screens of #316 stainless steel. These screens are separated by ⅛-inch spacers and decrease in mesh size so that the dispersion first passes a 14-mil screen, then a 9-mil screen, and finally a 4-mil screen. The dispersion of swollen solvated collagen fibrils so obtained analyzes 1.09% solids and has a pH of 2.52.

The above collagen dispersion (300 grams) is poured into a stainless-steel tray measuring 15" x 9" x 1½" and smoothed out. A Dacron tulle is placed flat on the surface of the collagen dispersion and covered with another 300 grams of collagen dispersion. The tray is frozen in a sub-zero cabinet at —20° C. overnight. The frozen sandwich is then removed from the tray and immersed in a circulating bath containing 5 liters of 99% isopropanol and 25 milliliters of concentrated ammonium hydroxide at room temperature. After approximately four hours, the isopropanol solution is replaced with 5 liters of a fresh solution and the dehydration is continued overnight at room temperature. The isopropanol solution containing the water extracted is removed and a third bath of 99% isopropanol is used in the further dehydration of the collagen. The third bath is replaced in turn with a fourth bath of 99% isopropanol containing 0.4% formaldehyde, the dehydrating time amounting to 6 to 8 hours in both the third and fourth baths. At this time, the collagen fibrils are practically free of water and the Dacron-collagen film may be squeezed repeatedly between rubber rollers and air-dried in an oven at 45° C. overnight without damage.

The product so obtained is illustrated in FIGURE 1. The collagen fibrils of the surface coatings **11** and **12** extend through the openings **13** in the fabric **14** and make it difficult to separate the collagen layer from the fabric.

EXAMPLE II

A collagen dispersion is prepared according to the general procedure described in Example I above from 391 parts of sliced beef leg tendon and 17,110 parts of distilled water containing 7.3 parts of glacial acetic acid. This dispersion contains 0.8% solids and is placed in trays and reinforced by immersing a Teflon fabric in the dispersion so that the fabric is suspended about halfway between the surface of the dispersion and the bottom of the tray. The contents of each tray is frozen and transferred in the frozen condition to a wire mesh frame. The frozen mass from each tray is dehydrated and coagulated by immersing in a circulating bath containing 60,000 parts of 99% isopropanol, 300 parts of concentrated ammonium hydroxide and 240 parts of formaldehyde (37% solution) at room temperature for approximately 8 hours. The circulating isopropanol bath is then replaced with a freshly constituted bath and the dehydration is continued overnight. This second bath is replaced with a third bath containing 99% isopropanol at room temperature and the dehydration is continued for 8 to 16 hours after which a fourth bath consisting of 99% isopropanol is substituted for the third bath. After dehydration for 8 to 16 hours in the fourth bath, the collagen coated Teflon fabric is compressed at about 128 pounds per square inch pressure and air-dried at 50° C. overnight.

EXAMPLE III

Example II above was repeated, substituting for the 7.3 parts of glacial acetic acid employed in that example 59.5 parts of cyanoacetic acid. The resulting prosthesis is sterilized by electron beam irradiation and may be used by the surgeon for hernia repair.

EXAMPLE IV

A collagen dispersion is prepared according to the general procedure described in Example I above from 216 parts of sliced beef leg tendon and 9,780 parts of distilled water containing 50 parts of malonic acid. This dispersion contains 0.8% solids and is used to coat both sides of a Teflon net fabric as described in Example I. The Teflon-collagen composition is frozen and transferred in the frozen condition to a wire mesh frame. The frozen mass is dehydrated and coagulated by immersing in a circulating bath containing 45,000 parts of 99% isopropanol and 1330 parts of concentrated ammonium hydroxide at room temperature for approximately 8 hours. The freshly constituted bath and the dehydration is continued overnight. This second bath is replaced with a third bath containing 99% isopropanol at room temperature and the dehydration is continued for 8 to 16 hours after which a fourth bath consisting of 99% isopropanol is substituted for the third bath. After dehydration in the fourth bath for 8 to 16 hours, the resulting product is air-dried at 50° C. overnight.

The film so obtained is tanned by immersing for 30 seconds in a solution of 0.4 part of pyrogallol, 0.1 part tetrasodium ethylenediamine tetraacetic acid and 99.5 parts of water adjusted to pH 8.3 with ammonium hydroxide and redried in an oven at 50° C. for 6 hours.

The film is next immersed for 30 seconds in a solution of chromium (III) sulfate comprising 0.8 part of chromium as chromic oxide, 0.5 part of lactic acid (85%), 0.24 part of formaldehyde and 98.46 parts of water adjusted to pH 2.7 with sodium hydroxide, and dried in an oven at 50° C. overnight.

EXAMPLE V

A glass tube having an inside diameter of about ¾ inch is fitted with a one-hole stopper of rubber through which a 5/16-inch glass rod is placed so that the glass rod extends coaxially within the glass tube. Before placing the glass rod and rubber stopper in position, the glass rod is covered with a piece of rubber tubing and a cylindrical tube of open-mesh woven Dacron about ⅝ inch in diameter is slipped over the glass rod and rubber tube.

The glass tube and glass rod are assembled in an upright position with the bottom of the Dacron fabric tube resting on the rubber stopper. A dispersion of swollen collagen fibrils (0.08% collagen in 0.05 N acetic acid) is poured into the glass tube while maintaining the fabric tube in a coaxial position and equally spaced between the rubber tube and glass tube so that both sides of the fabric are coated with the collagen dispersion. This mold with the dispersion and fabric in place is then frozen in the vertical position for at least 4 hours at —20° C.

The mold is then placed in a static coagulation bath consisting of 2 liters of isopropanol alcohol, 30 cubic centimeters of concentrated ammonia (25%) and 10 cubic centimeters of formaldehyde (37% solution) at room temperature and the mold is maintained in the solution for 16 hours. The glass rod covered with the rubber tube and the formed collagen tube is then removed and placed in a dehydrating bath consisting of 2 liters of isopropanol alcohol. The collagen tube is left in this bath for an additional 16 hours to complete the dehydration.

After dehydration, the rubber tube with the collagen tube on it, is very carefully slid off the glass rod and the rubber tube is removed from the interior of the collagen tube by pulling on both ends of the rubber tube, thereby stretching the rubber tube and reducing its diameter. After the collagen tube is removed from the rubber tubing, it is plasticized in a bath consisting of 2 liters of 90% isopropanol alcohol (10% water) containing 5% glycerine. This plasticizing operation is optional. After 24 hours in the plasticizing bath, the collagen tube is supported on a glass rod and air-dried. The resulting product is illustrated in FIGURE 5.

EXAMPLE VI

Tanned Dacron reinforced collagen films prepared by the method described in Example II above are rolled and sewed to form tubes about 1 centimeter in diameter and sterilized by irradiating with an electron beam. These tubes are used to replace segments of the abdominal aorta in mongrel dogs averaging 15 kilograms in weight. The animals were sacrificed at varying periods of time up to 8 months.

Grossly, the Dacron-collagen prothesis shows an orderly pattern of organization at varying periods of time following insertion of the graft. The prostheses are all 5 centimeters long, divided into two types—thick and thin, according to the amount of impregnated collagen. No significant response difference can be detected in the two types. However, there is a significant difference, particularly in regard to initial hemorrhage, between the untreated collagen and the collagen that has been tanned. The following results are observed:

One week

Gross specimen.—The one-week specimens are contained in a fibrous envelope which is not in any way adherent to the prosthesis. The interstices of the graft are still occluded by the impregnated collagen and the lumen is lined by a red, granular coagulum.

Microscopic section.—Sections of the proximal portion show an artefactual separation of the Dacron prosthesis from the surrounding fibro-adipose tissue.

The fibro-adipose tissue shows active fibroplasia and a minimal inflammatory infiltrate, comprised of polymorphonuclear leukocytes, a few lymphocytes and some plasma cells. The prosthesis itself shows the open meshwork with the interstices filled by a series of haphazardly-arranged, tangled fibrils of bovine collagen with irregular interstices containing small numbers of erythrocytes. The surface of the prosthesis is covered by fibrin clot containing a few histiocytes, erythrocytes and neutrophils. There is no tongue-like extension of fibroplasia extending from the severed end of the aorta out into the graft, although there is a focal zone of reactive hyperplasia with capillaries and occasional inflammatory elements present at the anastomotic line. The lining consists of a thin fibrin layer, maximally 1 millimeter in thickness.

Two weeks

Gross specimen.—By two weeks, the fibrous envelope is partially adherent but may be readily dissected free by lysis of delicate fibrous and fibrinous bands. The wall of the prosthesis and the lining are similar to those of the one-week specimen.

Microscopic section.—The two-week specimen shows a lack of inflammatory reaction similar to the specimen at one week. The zone of fibrosis and fibroplasia in the fibro-adipose tissue adjoining the prosthesis is more mature, but as yet, there is no extension of fibroblasts into the prosthesis except at microscopic points. At the anastomosis, a well developed zone of fibroplasia extends across the anastomotic line onto the surface of the prosthesis and this tongue, in turn, is covered in part by endothelium. The prosthesis itself appears quite similar to the one-week specimen. The impregnated collagen appears well retained. The lining surface of the prosthesis now appears to be more dense fibrin with enmeshed erythrocytes and is somewhat thinner than the fibrin lining of the one-week specimen.

Three weeks

Gross specimen.—At three weeks the fibrous envelope is more adherent than earlier, but still may be separated by forceful dissection. The lining is smoother and averages approximately one millimeter in thickness.

Microscopic section.—The peripheral enveloping zone of fibrosis is wider than previously and there is extension of fibroblasts into the interstices of the prosthesis at numerous points. Foreign body reaction to the Dacron of the prosthesis is present but still remains minimal. The inflammatory reaction is largely composed of histiocytes containing hemosiderin, plasma cells and lymphocytes. A mural fibrin thrombus is present and is focally organized, particularly at the anastomotic line. This organization is part of the tongue of advancing fibroblasts.

Four weeks

Gross specimen.—The four-week specimen is finely swedged to the fibrous envelope. A thin semi-transparent membrane covers the anastomotic lines.

Microscopic section.—A dense, surrounding fibrous envelope of mature collagenous connective tissue stains bright green in a Masson trichrome stain. The prosthesis adheres densely to this envelope and there are irregular extensions of this material into the interstitial areas of the prosthesis, most particularly between the Dacron meshwork. The interstices of the bovine collagen are now partially filled with green-staining collagenous connective tissue from the host. Inflammatory reaction is meager. The lining of the prosthesis consists of a zone of fibrous tissue apparently covered by endothelium that ranges in thickness from about 1 millimeter to less than 0.1 millimeter, being thinnest in its more central extent. This lining is continuous with the lining of the dog's aorta.

Five weeks

Gross specimen.—The five-week specimen is essentially the same as the four-week specimen.

Microscopic section.—The appearance is substantially the same as that of the four-week specimen, although there is slightly less of the bovine collagen remaining and more of green-staining collagen contributed by the host, particularly at the anastomosis.

Two-and-a-half months

Gross specimen.—The organization is almost complete. The fibrous envelope is firmly adherent and the lumen is lined by a thin, well-defined, smooth, semi-transparent grayish membrane.

Microscopic section.—There is notable progress of the fibrous tissue ingrowth into the prosthesis. Only an occa-

sional, longitudinally, oriented wavy thread of the original prosthetic impregnation remains.

Eight months

Gross specimen.—The prosthesis is solidly united to the fibrous envelope. In cross section, the entire thickness of the prosthetic wall is slightly less than 2 millimeters. The lumen is covered by a smooth, glistening, grayish membrane that appears continuous with the intima of the host artery.

Microscopic section.—The prosthesis is completely organized by mature collagen that fills all of the interstices and has replaced all of the original bovine collagen fibrils except for a rare remaining fibril. The luminal aspect of the prosthesis is smooth and is continuous with the dog's aorta. There is virtually no inflammatory reaction. The Dacron material of the prosethetic meshwork appears embedded in a continuous, rather uniform collagen mass. Externally, the prosthesis blends with the adjoining fibroadipose tissue.

EXAMPLE VII

A Teflon fabric **14** is rolled to form a cylinder as indicated in FIGURE 3 and the fabric is sewed with Dacron thread **15** to a surrounding Teflon helix **16** as illustrated in FIGURE 3. The supporting helix prevents the fabric tube from kinking or collapsing. This structure is covered with collagen fibrils on both sides by the procedure outlined in Example V. The resulting tube resists fraying at the ends and is adapted for use in grafts that traverse the inguinal fold or the popliteal space.

EXAMPLE VIII

A Dacron fabric **14** is sewed to form a cylinder as indicated in FIGURE 4 and the fabric is sewed with Dacron thread **15** to spaced surrounding Teflon rings **17** as illustrated in FIGURE 4. The supporting rings **17** serve the same function as the helix **16** in FIGURE 3 and prevents the fabric tube from kinking or collapsing. This structure is covered by collagen fibrils on both sides by the procedure outlined in Example V. The resulting article after electron beam sterilization is adapted for use in clinical vascular surgery. The finished tube is quite flexible and may be flexed repeatedly without collapsing.

EXAMPLE IX

A collagen dispersion (0.86% solids) is extruded into a circulating acetone dehydrating bath through a stainless steel spinnerette drilled with 192 openings arranged in concentric circles. Each opening in the spinnerette is approximately 18 mils in diameter and each opening has a 30° taper from this diameter at a point 34 mils from the spinnerette surface to a 3/32 inch opening at the bottom surface of the spinnerette. The multifilament that emerges from the acetone dehydrating bath is wrapped 1½ times around a godet and passes to a false twister. Warm air is circulated to dry out the multifilament as it contacts the false twister which is rotated at about 200 r.p.m. Under these conditions, the individual filaments that make up the multifilament do not bond together. The multifilament, which consists of 192 individual collagen threads, may be collected directly on a takeup spool.

The collagen multifilament so obtained may be woven together with non-absorbable multifilament or yarn such as Dacron yarn to form fabrics and tubes that are useful in surgery. It is desirable that the collagen multifilament be tanned by methods well-known in the art to increase the strength and in vivo digestion time of the collagen. The collagen multifilament may be tanned prior to or after weaving. If the collagen multifilament is tanned prior to weaving, a collagen strand may conveniently be formed by twisting the collagen multifilament and drying under tension. Under these conditions, the individual filaments cohere to form a strand which may be woven into a fabric or tube with non-absorbable threads or yarn.

While the invention has been described in detail according to the preferred method of carrying out the process and yielding the products, it will be obvious to those skilled in the art, after understanding the invention, that changes and modifications may be made (without departing from the spirit or scope of the invention) and it is intended in the appended claims to cover such changes and modifications.

What is claimed is:

1. A method of manufacturing surgical prostheses which comprises the steps of:
impregnating a non-absorbable fabric with an aqueous acid dispersion of swollen collagen fibrils;
freezing the aqueous acid dispersion of swollen collagen fibrils;
immersing the frozen mass in a water-miscible organic solvent containing sufficient base to neutralize the acid present in said dispersion;
removing the resulting structure from the organic solvent; and,
drying the resulting structure.

2. A method of manufacturing surgical prostheses which comprises the steps of:
knitting an open mesh tube;
impregnating this tube with an aqueous acid dispersion of collagen fibrils, whereby said collagen fibrils fill the interstices of the tube;
freezing the aqueous acid dispersion of collagen fibrils;
immersing the frozen mass in acetone containing sufficient ammonium hydroxide to neutralize the acid present in said dispersion, whereby the collagen fibrils are dehydrated and coagulated;
removing the structure so obtained from the acetone; and,
drying.

3. A surgical prosthesis comprising:
an open mesh non-absorbable fabric, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer, and impregnated with a body absorbable substance consisting of collagen fibrils, whereby the prosthesis is rendered bloodtight.

4. A surgical prosthesis comprising:
an open mesh non-absorbable tulle, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer, the interstices of which are filled with a body absorbable substance consisting of collagen fibrils, whereby the prosthesis is rendered bloodtight.

5. A surgical prosthesis comprising:
an open mesh non-absorbable cylindrical tube, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer, and coated on at least one side with a body absorbable substance consisting of collagen fibrils, whereby the prosthesis is rendered bloodtight.

6. A surgical prosthesis comprising:
a knit open mesh non-absorbable cylindrical tube, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer, and coated on at least one side with a body absorbable substance consisting of collagen fibrils, whereby the prosthesis is rendered bloodtight.

7. A surgical prosthesis comprising:
a woven open mesh non-absorbable cylindrical tube, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer, and coated on both sides with a body absorbable substance consisting of collagen fibrils, whereby the prosthesis is rendered bloodtight.

8. A surgical prosthesis comprising:
a non-absorbable tulle, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer, and

shaped to form a cylindrical tube; a plurality of reinforcing non-absorbable rings manufactured of tetrafluoroethylene polymer surrounding and spaced along the axis of said tube; said tube being encapsulated in a matrix of collagen fibrils.

9. A surgical prosthesis comprising:

a non-absorbable fabric, manufactured of material selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer fabrics, and shaped to form a cylindrical tube; a nylon helix coiled around said tube; the tube and surrounding helix being coated with collagen fibrils.

10. A surgical prosthesis comprising a bloodtight knitted fabric consisting of a non-absorbable yarn selected from the group consisting of polyethylene terephthalate, tetrafluoroethylene polymer yarn and mixtures thereof; and a body absorbable extruded multifilament consisting of collagen fibrils, the interstices between the non-absorbable yarn of the fabric being sufficiently large to permit easy invasion by the host tissue during the healing process.

11. A surgical prosthesis comprising a bloodtight fabric woven with filling yarns of non-absorbable threads selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer threads; and warp yarns of body absorbable extruded strands consisting of collagen fibrils, the non-absorbable threads of the fabric being separated sufficiently from each other to permit easy invasion by the host tissue during the healing process.

12. A surgical prosthesis comprising a bloodtight fabric woven with filling yarns of non-absorbable threads selected from the group consisting of polyethylene terephthalate and tetrafluoroethylene polymer threads; and warp yarns of a body absorbable extruded multifilament consisting of collagen fibrils, the interstices between the non-absorbable threads of the fabric being sufficiently large to permit easy invasion by the host tissue during the healing process.

13. A surgical prosthesis comprising a bloodtight woven fabric consisting of a non-absorbable yarn selected from the group consisting of polyethylene terephthalate, tetrafluoroethylene polymer yarn and mixtures thereof; and a body absorbable extruded multifilament consisting of collagen fibrils, the interstices between the non-absorbable yarn of the fabric being sufficiently large to permit easy invasion by the host tissue during the healing process.

14. A surgical prosthesis comprising a bloodtight braided fabric consisting of a non-absorbable yarn selected from the group consisting of polyethylene terephthalate, tetrafluoroethylene polymer yarn and mixtures thereof; and a body absorbable extruded multifilament consisting of collagen fibrils, the interstices between the non-absorbable yarn of the fabric being sufficiently large to permit easy invasion by the host tissue during the healing process.

15. A surgical prosthesis comprising a bloodtight crocheted fabric consisting of a non-absorbable yarn selected from the group consisting of polyethylene terephthalate, tetrafluoroethylene polymer yarn and mixtures thereof; and a body absorbable extruded multifilament consisting of collagen fibrils, the interstices between the non-absorbable yarn of the fabric being sufficiently large to permit easy invasion by the host tissue during the healing process.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,272,204 September 13, 1966

Charles Artandi et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 46, after "The" insert --
circulating isopropanol bath is then replaced with a --.

Signed and sealed this 1st day of August 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents