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Rambert et al.

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[54] **METHOD OF AND PROSTHESIS FOR RESTORING LIGAMENTS OF A JOINT**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **3/1**; 128/92 C; 128/92 B

[51] **Int. Cl.** **A61f 1/24**

[58] **Field of Search** ..... 3/1; 128/92 C, 92 R, 92 B, 128/92 D, 334 R, 334 C

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[57] **ABSTRACT**

A method of and device for replacing a damaged ligament in a joint such as a knee, wherein a sheath group of fibers is passed through a tunnel formed in the bore of the joint and opening at the point of attachment of the natural ligament. The artificial ligament is anchored by a pair of plates, one on each bone of the joint.

16 Claims, 11 Drawing Figures

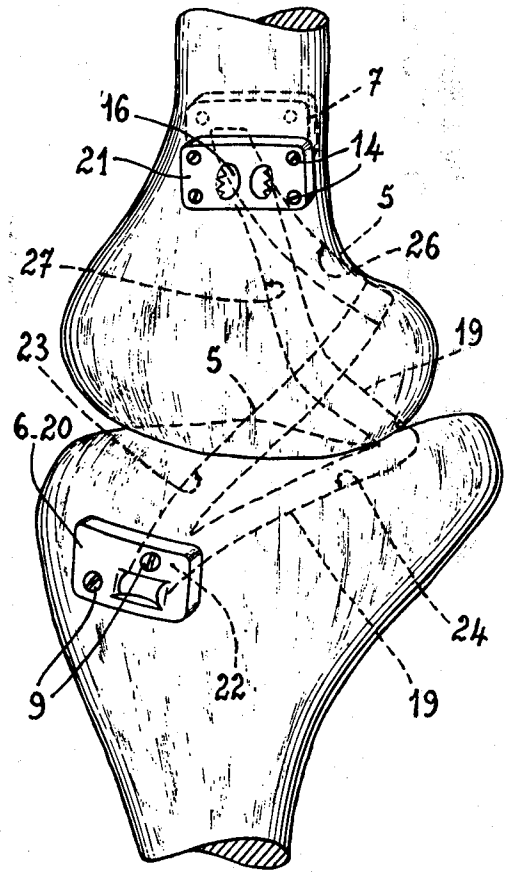


FIG. 7

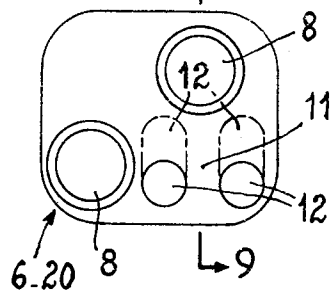


FIG. 9

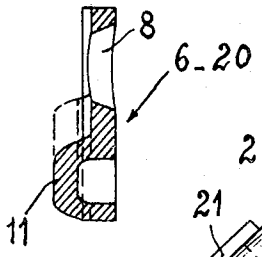


FIG. 8

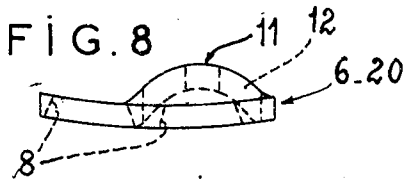


FIG. 1

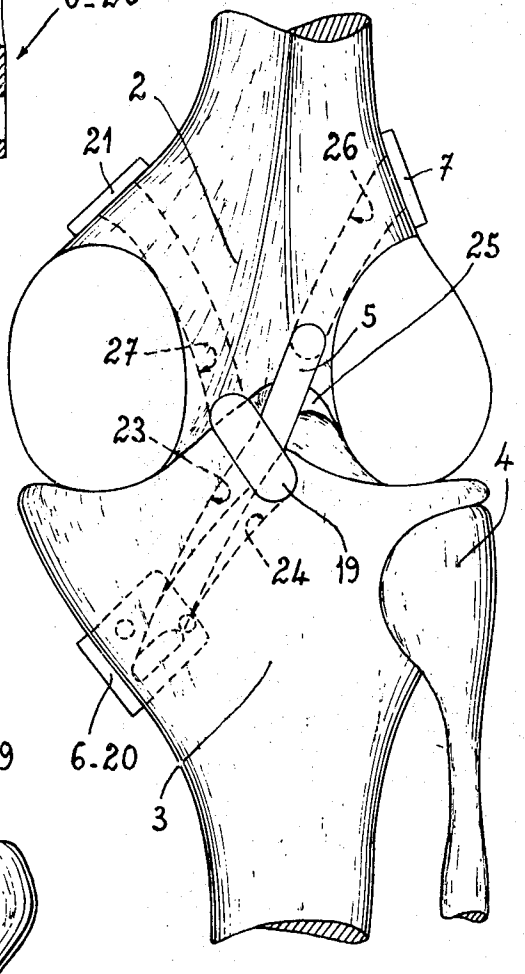


FIG. 2

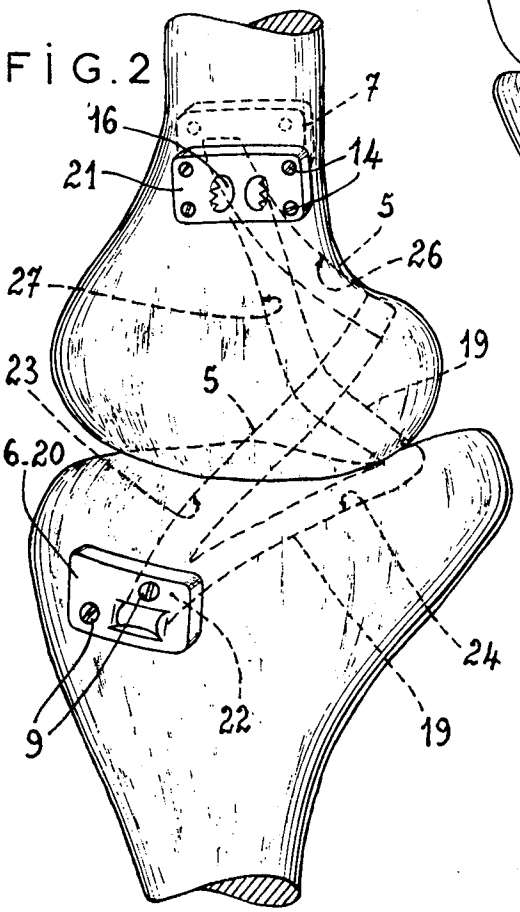


FIG. 10

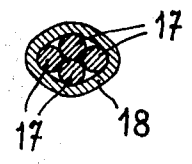


FIG. 3

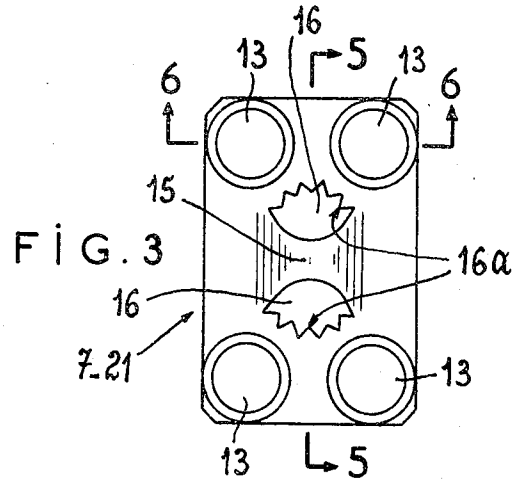


FIG. 5

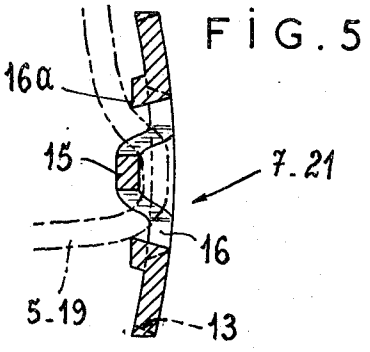


FIG. 4

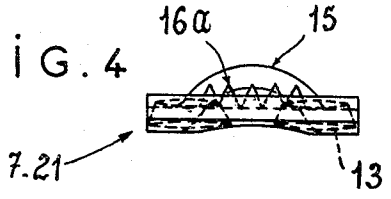


FIG. 6

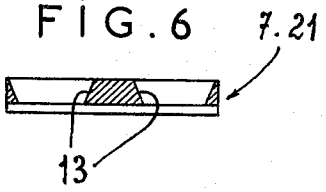
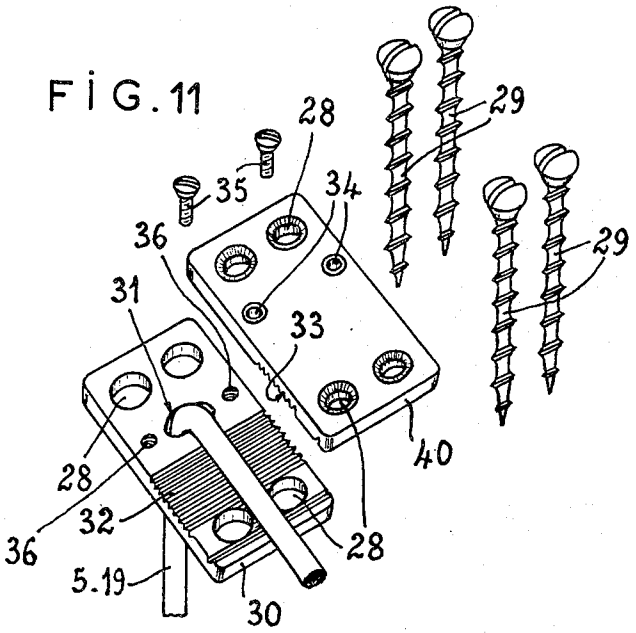


FIG. 11



METHOD OF AND PROSTHESIS FOR RESTORING LIGAMENTS OF A JOINT

The present invention relates to a method for restoring the ligaments of a joint and a prosthesis for carrying out the method. More particularly, the invention relates, though not exclusively, to restoring the crossed ligaments of the knee.

The crossed ligaments control the antero-posterior movement of the tibia under the femur, generally called a "sliding movement."

Currently, the restoration of these ligaments upon recent or earlier traumatic rupture, is carried out either by reinsertion, i.e., by stitching the torn ligament, or by replacement of the torn ligament with a strip of skin or natural tissue.

These methods have three drawbacks:

1. According to the first method, either the ligament has already lost its vascularization and shortly after the operation it degenerates, or it is too short and thus it alters the kinematics of the knee joint;
2. according to the second method, the grafted member is able to control the sliding movement but the material becomes distended or deteriorates over a shorter or longer period and;
3. in both cases, from the physiological point of view, there is insufficient desired torsion or tension for restoring the movement of the joint.

The method according to the invention has as its object to restore to the joint the operation and shape of its ligaments.

To this end, the method comprises boring in each bone of the joint, a tunnel opening in the articular gap substantially at the point of attachment of the torn or damaged ligament, passing an artificial ligament through each of these tunnels and of securing this artificial ligament to the bones of the joint at free outer ends of these tunnels, after placing the ligament under tension to the desired value.

According to a simple embodiment of the invention, the prosthesis for carrying out this method comprises at least one ligament constituted, by at least one pair of strands of thread forming, at one of their ends, a loop and wrapped in a sheath and by two fastening plates comprising a part in the form of a bridge and each of which is able to be fixed by screws to one of the bones, in correspondence with the free end of the tunnel of the bone in question, the part in the shape of a bridge of one of the plates being previously engaged in the loop-shaped end of the artificial ligament, whereas the bridge-shaped part of the other plate is provided with means for ensuring the retention of the free end of the artificial ligament.

Advantageously, the retaining means is constituted by teeth cut out in the part of the plate which surrounds its bridge-shaped part; these teeth are so shaped that they only allow the artificial ligament to slide in a direction increasing its tension.

According to a variation of this prosthesis, the means capable of ensuring the retention of the free end of the artificial ligament are constituted by an auxiliary plate capable of being pressed against the first plate or main plate in order to clamp the said end of the artificial ligament.

For example, the means for pressing the auxiliary plate against the main plate may be simple screws.

Advantageously, at least two corresponding parts of the opposing faces of the main and auxiliary plates,

parts located in the region for positioning the free end of the artificial ligament, are provided with ridges.

Preferably, at least the sheath of the artificial ligament is made of a material which does not evoke any reaction rejecting the ligament.

For example, the sheath is advantageously made from a synthetic polymer material and the strands of the ligament from a product of the polyamide family of medical quality, of a diameter ranging from 1 to 5mm.

This attachment and this construction facilitate resetting of the bone around the artificial ligament, which will have the effect of easing pressure on the plates.

According to a preferred embodiment of this prosthesis, the constituent strands of the ligament are joined to each other and to the sheath by appropriate stitching or by an adhesive of medical quality.

In the case where the prosthesis is intended to replace the front crossed ligament of the knee, the fibers and the sheath of the artificial ligament are twisted such that the angle of the part of this ligament located in the inter-articular gap is comprised between **45°** and **90°** and preferably is equal to **60°**, this twisting being fixed and the pitch of the helix being right-handed or left-handed depending on whether it is a left or right knee.

This twisting makes it possible to correct the antero-posterior displacement perfectly without limiting the bending or extension of the knee. In fact, without twisting, it is still possible to limit the antero-posterior movement, but the bending of the knee would thus be limited, this is why the relationships of torsion and length have been studied in particular.

In the case where the prosthesis is intended to replace the rear crossed ligament of the knee, the fibers and the sheath of the artificial ligament are twisted such that the twisting angle of the part of this ligament located in the inter-articular gap is comprised between **10°** and **30°**, the pitch of the helix being right-handed or left-handed depending on whether it is a right or left knee.

Finally, in the case where the prosthesis is intended to replace both crossed ligaments of the knee, the two artificial ligaments are integral one with the other at one of their ends forming a loop and engaged on the bridge-shaped part of a tibial fastening plate, one of the strands of this loop intended to constitute the front ligament being twisted such that the twisting angle of its part located in the interarticular gap is between **45°** and **90°**, with a right or left-handed helix pitch depending on whether it is a left or right knee, whereas the other strand, intended to constitute the rear ligament is twisted such that the twisting angle of its part located in the interarticular gap is between **10°** and **30°**, with a right or left-handed helix pitch depending on whether it is a right or left knee.

The invention will be better understood with reference to the ensuing description, referring to the accompanying diagrammatic drawing, of an embodiment of a prosthesis for carrying out this method for restoring the crossed ligaments of a right knee:

FIGS. **1** and **2** are respectively rear and left-hand views of the knee joint provided with the prosthesis according to the invention;

FIG. **3** is a front view of the plate for fastening the front ligament to the femur or rear ligament;

FIG. **4** is a plan view of the plate of FIG. **3**;

FIGS. 5 and 6 are sectional views on lines 5—5 and 6—6 of FIG. 3 respectively;

FIGS. 7 and 8 are respectively a front view and a side view of a plate for securing to the tibia front and rear ligaments;

FIG. 9 is a sectional view on line 9—9 of FIG. 7;

FIG. 10 is a cross-sectional view of an artificial ligament according to the invention;

FIG. 11 is an exploded perspective view of a variation of the system for attaching to the femur front or rear crossed ligaments.

FIGS. 1 and 2 show the joint of a right femur, i.e., the lower end 2 of a femur and the upper end 3 of a tibia.

FIG. 1 also shows the upper end 4 of the fibula.

The prosthesis according to the invention mainly comprises a front ligament 5 and a rear ligament 19, each of which is fastened, at one of its ends, to a tibial plate 6 or 20 respectively and, at its other end, to a femoral plate 7 and 21 respectively.

The tibial plates 6 and 20 are strictly identical and are shown in detail in FIGS. 7 to 9. Each of these plates comprises one or two holes 8 facilitating its attachment to the tibia by means of screws 9 and a part 11 in the form of a bridge separating two openings 12.

The femoral plates 7 and 21 are shown in detail in FIGS. 3 to 6.

Each of these plates has four holes 13 facilitating its attachment to the femur 2 by means of screws 14 and a part 15 in the form of a bridge separating two apertures 16.

Each front artificial ligament 5 or rear artificial ligament 19 is composed, as shown in FIG. 10, of two pairs of strands 17 of polyamide of medical quality having a diameter of 1 to 5mm. enclosed in a sheath 18 of synthetic polymer material not causing any reaction capable of rejecting the ligament.

Advantageously, the sheath 18 and the strand 17 are assembled by an adhesive of medical quality or by stitching.

In the example shown in the drawing, the two front and rear crossed artificial ligaments 19 are attached to the tibia 3 by means of a single tibial plate 6. It should nevertheless be noted that this arrangement is not obligatory. In this case, the terminal loop of the two ligaments 5 and 19 is common thereto and consequently, at this end, the two ligaments have a common stem 22.

Along the length of this common stem 22, the eight strands 17 of the two ligaments 5 and 19 are provided with a common sheath before being separated into two ligaments each comprising four strands 17 and a sheath 18.

In this embodiment, for the passage of the loop common to the two ligaments 5 and 19, the openings 12 of the tibial plates 6 have, as shown in broken line in FIG. 7, the shape of a slot.

In the case where only one of the crossed ligaments is replaced by this prosthesis, or if it is preferred to put two separate tibial plates 6 and 20 in position, the terminal loops of each of the ligaments 5 and 19 are separate and each of them is formed by the two pairs of strands 17 of the ligament in question. In this case, the openings 12 of each tibial plate 6 have, as shown in solid lines in FIG. 7, a circular shape.

Since the ligaments 5 and 19 are thus previously attached to one or two tibial plates 6, they are engaged in tunnels 23 and 24 respectively formed in the tibia 3 in order to open into the inter-articular gap 25 at the normal attachment point of the natural ligament which is replaced.

In the case where a single tibial plate 6 is used, the two tunnels 23 and 24 are bored in the tibia 3 from the location of the tibial plate 6 located on the outer side of this tibia.

The ligaments 5 and 19 are then engaged in the tunnels 26 and 27 respectively bored in the femur 2 from the locations of the femoral plates 7 and 21 so as to open into the inter-articular gap at the attachment points of the natural ligaments.

The femoral plates 7 and 21 are respectively located on the right and left-hand side of the femur 2.

The free ends of the ligaments 5 and 19 leaving the tunnels 26 and 27 are engaged on the bridge-shaped part 15 of the femoral plate, 7 and 21 respectively, passing through apertures 16 in the latter. The part of the ligament 5 or 19 placed astride the bridge 15 is accessible to the surgeon and may thus be used by the latter for pulling the ligament in question and giving it the desired tension.

The aperture 16 is provided with teeth 16*a* opposing the withdrawal of the ligament 5 or 19 after it has been placed under tension.

FIG. 11 shows a particularly advantageous variation of the femoral plate 7 and 21. In this variation, each femoral plate actually comprises two plates, namely a base plate 30 fulfilling the function of the plate 7 or of the plate 21 and an auxiliary plate 40 fulfilling the function of means retaining the ligament 5 or 19, replacing the teeth 16*a* of the aperture 16.

Each plate 30 and 40 of rectangular section, has four holes 28 corresponding in pairs and intended for the passage of four screws 29 to be screwed into the tibia 3. The four holes 28 are arranged substantially at the four corners of the plates 30 and 40.

In addition, each main plate 30 has an aperture 31 for the passage of the ligament 5 or 19 in question and ridges 32 in the region of its upper side against which said ligament is placed when it is put under tension.

The auxiliary plate 40 has corresponding ridges 33 in its part located opposite the region provided with ridges 32 of the main plate.

Finally, according to an advantageous arrangement of the invention, in order to avoid that the loosening of the screws 29 risks causing a slackening of the associated artificial ligament, the auxiliary plate 40 has two holes 34 for the passage of two screws 35 and the main plate 30 comprises two tapped holes 36 corresponding to the holes 34. Thus, by means of the screws 35, it is possible to press the auxiliary plate 40 against the main plate 30 and ensure absolute retention of the ligament in question.

According to another feature of the invention, the front ligament 5, before it is filed in place, is twisted in order to have a twisting angle which, over its length located in the inter-articular gap 25, has a value comprised between 45° and 90° and preferably equal to 60°.

This torsion which is fixed in order to provide zero torque in the rest position of the knee, provides return torque for each inner or outer rotation of the knee, whereas in the case of an outer rotation, the two crossed ligaments 5 and 19 become uncrossed. Moreover, the pitch of the helix of this twisting is right or left-handed depending on whether the knee is a left or right knee.

Furthermore, the rear ligament **19** which serves as a support for the front ligament **5** is, before it is put in position, over its length located in the inter-articular gap **25**, twisted in order to have a twisting angle comprised between **10°** and **30°**. Moreover, the pitch of the helix of this twisting is right or left-handed depending on whether the knee is a right or left knee.

The prosthesis according to the invention thus makes it possible to regulate to the desired value, the torsion and length of each of the ligaments **5** and **19**.

It was previously stated that the sheath **18** of each ligament was made from synthetic polymer material. This material has the advantage of promoting resetting of the bone on the ligament. Consequently, the pressure on the corresponding plates will be eased.

It may also be considered that in the inter-articular gap **25**, the surface of the prosthesis will be covered with a synovial substance or a tissue similar to the latter facilitating perfect tolerance and easy sliding.

We claim:

1. A method of restoring ligaments of a joint, comprising the steps of boring, in each bone of the joint, a tunnel opening into the articular gap substantially at the attachment point of the torn or damaged ligament; engaging in each of these tunnels, an artificial ligament; and attaching this artificial ligament to the free outer ends of these tunnels after putting the artificial ligament under tension at the desired value.

2. A prosthesis for restoring ligaments of a joint, comprising at least one artificial ligament constituted, by at least one pair of strands of thread forming, at one of their ends, a loop and covered by a sheath and by two attachment plates comprising a part in the shape of a bridge and each of which is able to be fixed by screws to one of the bones corresponding to an end of a tunnel traversing the respective bone, the bridge-shaped part of one of the plates being previously engaged in the loop-shaped end of the artificial ligament whereas the bridge-shaped part of the other plate is provided with means capable of ensuring the retention of the free end of the artificial ligament.

3. The prosthesis according to claim **2**, wherein said means capable of ensuring the retention of the free end of the ligament on the bridge-shaped part of the plate intended for anchoring it is constituted by teeth cut out from the part of the plate which surrounds the said bridge-shaped part, these teeth being directed so that they allow sliding of the artificial ligament only in a direction increasing its tension.

4. The prosthesis according to claim **2**, wherein said means capable of ensuring the retention of the free end of the artificial ligament is constituted by an auxiliary plate capable of being pressed against said other plate in order to compress said free end of the artificial ligament.

5. The prosthesis according to claim **4**, wherein the means for pressing the auxiliary plate against said other plate is constituted by screws.

6. The prosthesis according to claim **4** wherein at least two corresponding parts of the opposed sides of said other and auxiliary plates, located in the region for positioning the free end of the artificial ligament, are provided with ridges.

7. The prosthesis according to claim **2** wherein the sheath of said artificial ligament is made from a material which does not cause any rejection reaction of the organism receiving the prosthesis.

8. The prosthesis according to claim **7** wherein said material of the sheath is a synthetic polymer material.

9. The prosthesis according to claim **2** wherein the strands of said artificial ligament are made from a product of the polyamide family of medical quality.

10. The prosthesis according to claim **9** wherein the strands of said artificial ligament have a diameter between **1** and **5**mm.

11. The prosthesis according to claim **2**, wherein the strands and the sheath of said ligament are connected.

12. The prosthesis according to claim **11** wherein the strands and the sheath of said ligament are connected by stitching.

13. The prosthesis according to claim **11** wherein the strands and the sheath of said ligament are connected by means of an adhesive of medical quality.

14. The prosthesis according to claim **2** wherein, in the case of its application to the restoration of the front ligament of the knee, the strands and the sheath of the artificial ligament are twisted such that the twisting angle of the part of this ligament to be located in the inter-articular gap is comprised between **45°** and **90°** and preferably equal to **60°**, this twisting being fixed and the pitch of the helix being right or left-handed depending on whether the knee is a right or left knee.

15. The prosthesis according to claim **2** wherein, in the case of its application to the restoration of the rear ligament of the knee, the strands and the sheath of the artificial ligament are twisted such that the twisting angle of the part of this ligament to be located in the inter-articular gap is comprised between **10°** and **30°**, this twisting being fixed and the pitch of the helix being right or left-handed depending on whether the knee is a right or left knee.

16. The prosthesis according to claim **2** wherein, in the case of its application to the restoration of both front and rear crossed ligaments of a knee, the two artificial ligaments are integral one with the other at one of their ends forming a common loop and engaged on the bridge-shaped part of one of said plates for attachment to the tibia, one of the strands of this loop intended to constitute the front ligament being twisted such that the twisting angle of its part to be located in the inter-articular gap is comprised between **45°** and **90°** with a right-handed or left-handed pitch of the helix depending on whether the knee is a right or left knee, whereas the other strand, intended to constitute the rear ligament is twisted such that the twisting angle of its part to be located in the inter-articular gap is comprised between **10°** and **30°**, with a right or left-handed pitch of the helix depending on whether the knee is a right or left knee.

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