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TRIO

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INTRODUCTION

Sports medicine physicians have been concerned over the need for adequate knee protection both for post surgical and non-surgical patients. New surgical techniques being performed, and new instabilities being described, have created the need for new orthotic designs. These designs, while developed from conventional orthotic principles, have been modified for sports activity.

Conventional orthoses, such as the Knee-Ankle-Foot Orthosis, certainly provide adequate knee stability both in the M-L and A-P plane. The problem is that we not only wish to stabilize the knee, but also provide the patient with the ability to actively participate in sports.

The Knee-Ankle-Foot Orthosis which is attached to the shoe, or even an insert type stirrup, does not allow the patient adequate mobility for most athletic endeavors.

GOALS

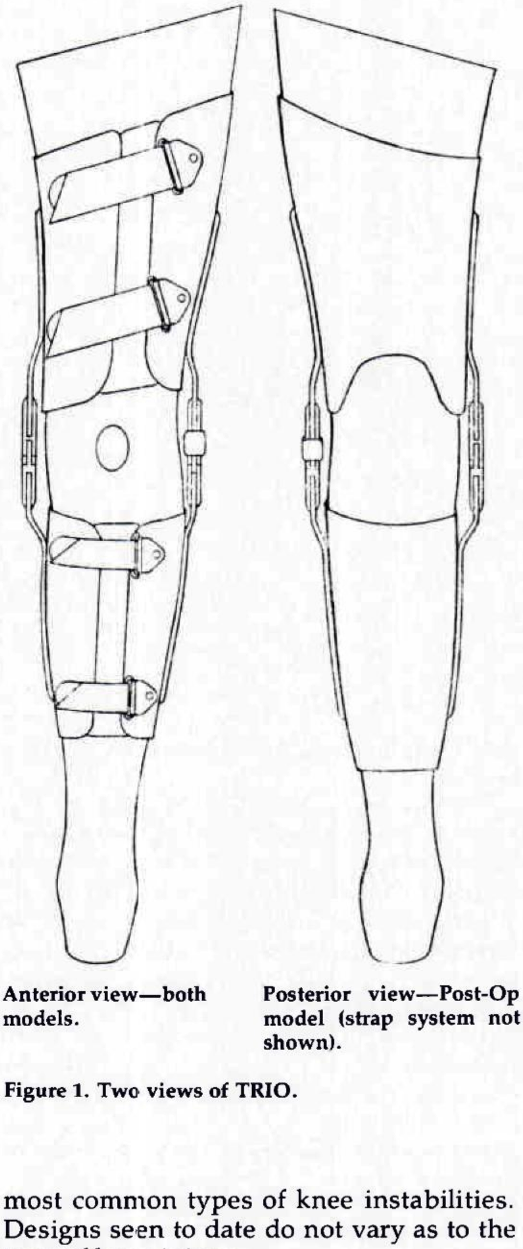
Goals in treating sports related knee injuries are different than other categories of knee instabilities. The main goal is to return the patient to sports activities without the injury resulting in permanent damage or disability.

It is important to commence rehabilitation of the patient as soon as possible after knee injury. Many physicians are sending their patients to sports medicine therapists for total rehabilitation programs five to six weeks after surgery. In order for them to safely give these patients adequate exercises, it is necessary to have some type of orthosis that will not only provide a controlled range of motion, but will also prevent abnormal motion or recurrence of the injury during the physical therapy program.

In formulating our goals for this orthosis, it was considered desirable to have it readily adaptable from a state of controlled motion to one of free motion or limited motion, so that it could be used in sports activities. When work began on the TRIO, most designs did not have the latitude to allow this conversion. The designs we had used prior to the TRIO were either for post-operative or sports activity, not both.

In the post-operative patient, maximum control and support are needed. The trimlines in the knee area are kept as close to the popliteal fossa as consistent with knee flexion. The patient's activity on the affected extremity is at a minimum until adequate strength and stability in the knee returns (see Figure 1, post-op version). When the patient is able to return to sports activity, the trimlines are modified to allow more freedom of motion. This is accomplished by creating openings in the posterior calf and thigh sections to allow for active muscle volume changes. The length is also shortened to eight inches. These modifications allow the patient with the potential of recurrent knee instability to return to his/her sports activities (see Figure 2, athletic version).

Another goal was to be able to modify the basic design of the orthosis so as to be able to address the specific needs of the



Anterior view—both models.

Posterior view—Post-Op model (strap system not shown).

Figure 1. Two views of TRIO.

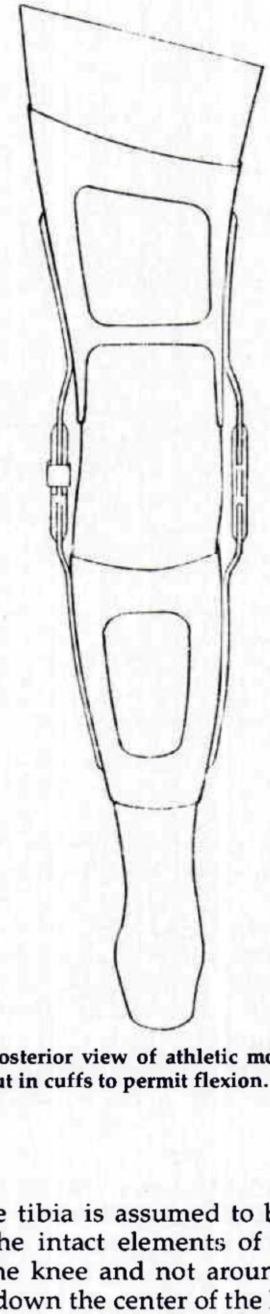


Figure 2. Posterior view of athletic model showing windows cut in cuffs to permit flexion. Strap system not shown.

most common types of knee instabilities. Designs seen to date do not vary as to the type of knee injury.

The most common knee instabilities are: antero-medial rotary, antero-lateral rotary, posterior cruciate rotary, and posterior-lateral rotary. In this categorization system[1], the instability is classified according to which side (medial or lateral) of the tibia moves relative to the femur and in which direction (anterior, posterior) it rotates. The tibia is assumed to be rotating around the intact elements of the sound side of the knee and not around the axis running down the center of the leg. Therefore, an antero-medial rotary instability means that the medial tibial condyle rotates anterior relative to the femur. All these instabilities have a linear, subluxing component, and in the posterior-cruciate rotary instability, this is the major element. Laxity of the posterior-cruciate ligament

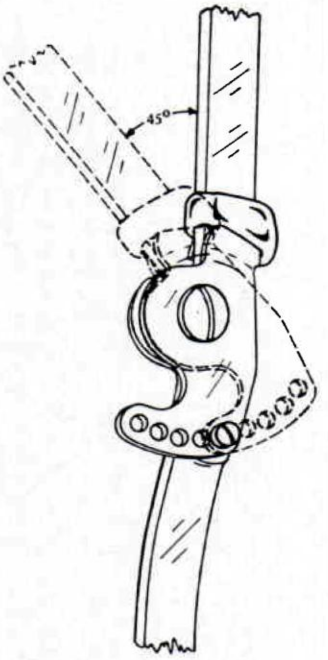


Figure 3. Knee joint with extension strap and drop lock. Maximum extension position can be varied from 0°-45°.

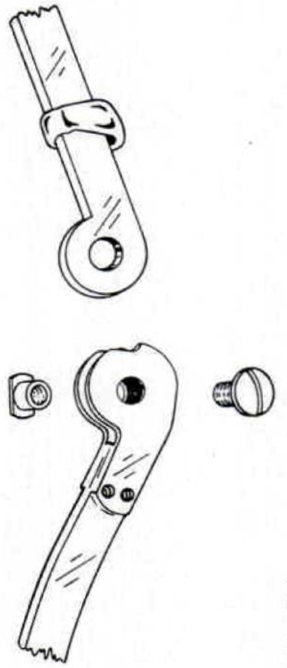


Figure 4. Free motion knee joint obtained by removing extension lock plate.

permits posterior subluxation of the tibia and some concomitant rotational instability.

A fifth goal was to devise a rotational control system that was more effective than the few designs on the market. It is felt that those orthoses with rotational straps offer little or no benefit. The need for internal or external rotation is paramount and depends upon the knee instability diagnosed.

The last goal was to have the orthosis self-suspending, since eliminating the use of Ace bandages or waist belts with a knee orthosis increases patient acceptance.

NEW DESIGN

With the goals set forth, various fabrication techniques were tried. All designs have the basic three point pressure system, but this design features total contact tibial and thigh components. The total contact concept was felt to be preferable, as the more area in contact, the less force per unit area.

Considerable thought was given to the types of thermoplastic materials available. Each was evaluated as to what it offered in strength, durability, and moldability. Today, with the many plastics available, it is important to choose the right material for an orthotic design. The material chosen is 3 mm. Subortholen and 3 mm. PE-LITE.® Subortholen offers the rigidity of polypropylene and the flexibility of polyethylene. Also, it has a unique characteristic known as cold flow. This allows for changing its shape without having to heat the material; a good quality to have as long as substantial force is required. If a low force could change its shape, the material would not provide adequate strength.

The joints used are a clevis type, manufactured by Durr-Fillauer Medical, Inc. This particular joint enables the user to add attachments to the joint head so as to control motion as desired. This feature is needed to protect some surgical repairs in the post-operative rehabilitation period as prescribed by the physician.

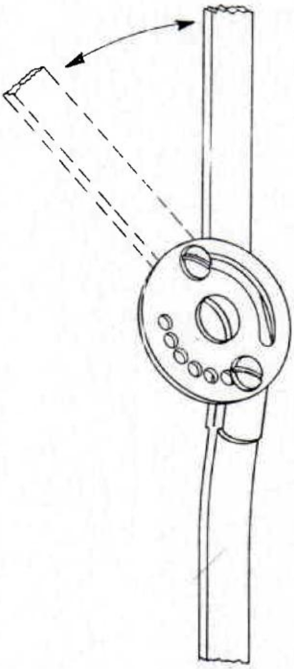


Figure 5. Knee joint which allows limited range of motion. Angles of maximum flexion and extension varied by the holes in the distal segment of the plate.

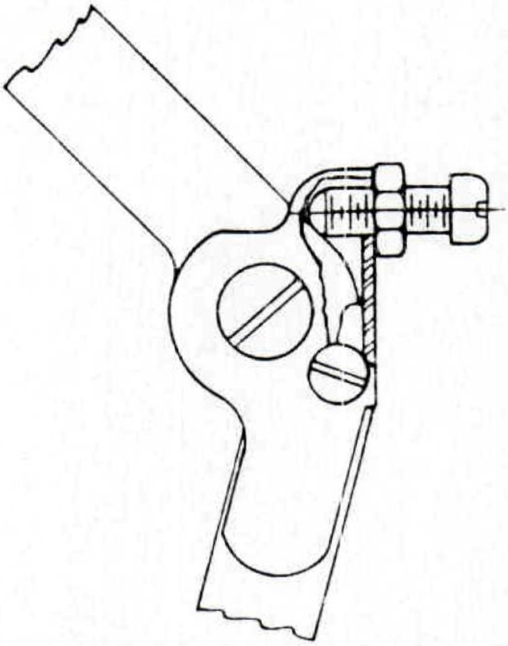


Figure 6. Knee joint with adjustable extension stop and screw in the distal portion of the joint to limit flexion.

The attachments or modifications to the joint are as follows:

1. A 0° to 45° adjustable extension stop or drop lock between 0° to 45° (Figure 3).
2. Free motion, converted from joint #1 above by removing the extension lockplate (Figure 4).
3. An extension flexion dial, which allows motion in a limited range (Figure 5).
4. Placement of two screws in the joint head, one in the anterior lower section for extension control, and a second screw in the posterior lower section which restricts flexion (Figure 6).

No specific explanation can be made as to when to use each design joint, as surgeons differ greatly as to what they wish to accomplish with knee orthoses. The surgeon should be queried to determine what range of motion he wishes to permit, and joint selection made accordingly. The most common instability seen in our office has been antero-medial rotary instability associated with anterior cruciate injuries, and the most common joint design used has been the second one listed above.

The rotation control system used consists of one or two rubber straps 3" wide. These straps are placed so as to provide a moment or torque at the knee that will create internal rotation if the patient has antero- or postero-medial instability and external rotation for antero- or postero-lateral instability. This moment, or torque, is produced by the combination of skin traction and the spiraling of the strap up the limb (see Figure 7). During swing phase, this moment positions the patient's leg so that at heel contact, the knee will be in proper alignment; the resistance of the elastic straps to abnormal rotation during weight bearing prevents any feeling of instability or "giving away." In addition, the straps are placed so that they will also provide either an anterior or posterior directed force on the tibia or femur to resist subluxation, depending on the type of instability.

In addition to the rotational straps, a 1" elastic pre-tibial strap producing a posteriorly directed force is used to retard anterior subluxation of the tibia in cases involving anterior cruciate tears.

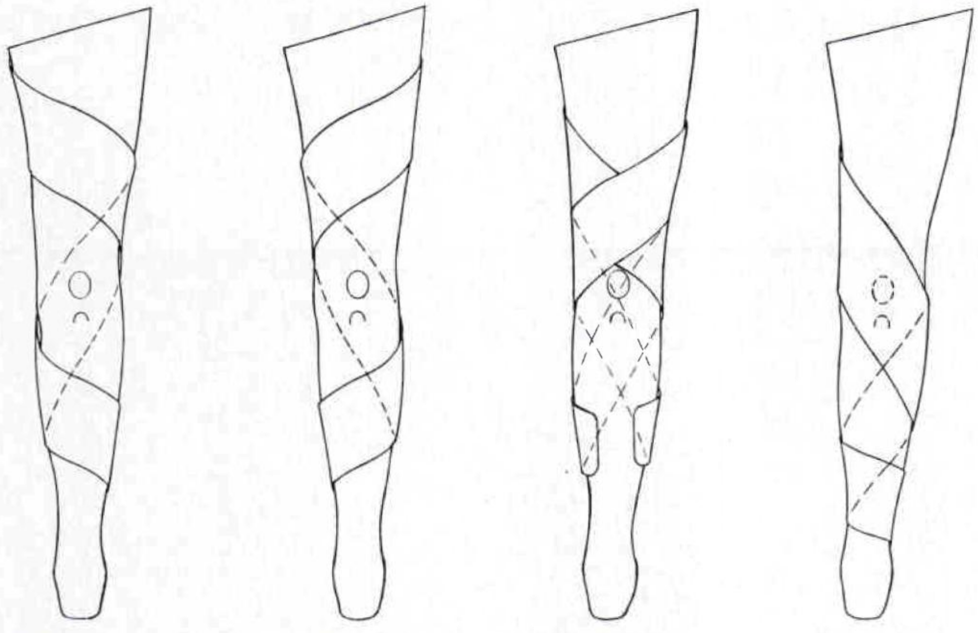


Figure 7. Rotary strap arrangement used with different types of instabilities.

Suspension is accomplished by bilateral supracondylar wedges that lock the orthosis in position (see Figure 8). The medial wedge is located just proximal to the adductor tubercle. After the patient has been wearing the orthosis for eight to ten days, additional padding material to tighten the fit may be needed due to subcutaneous atrophy in this area.

FABRICATING TECHNIQUES

The procedure for fabricating this orthosis is no more difficult than with other designs. A measurement from knee center to perineum is taken. The length of both thigh and calf sections of the post-op model will be equal to two-thirds of this distance. The thigh and calf sections of the athletic model are equal to one-half of this measurement, but no less than eight inches. A plaster wrap of the leg is required. The wrap must extend from the groin to ankle. Prior to casting, the knee center is marked with an indelible pencil and during cast-

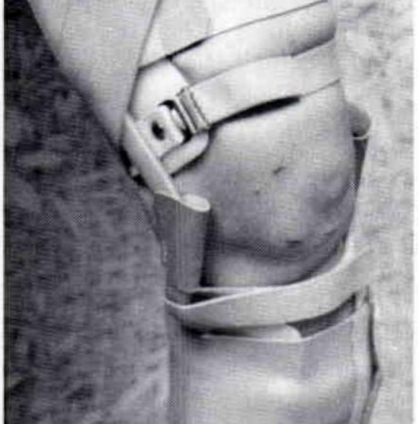


Figure 8. Medial view of completed orthosis showing supracondylar suspension and rotary system.

Figure 9. Cast of the patient's leg showing indentation proximal of the adducter tubercle.

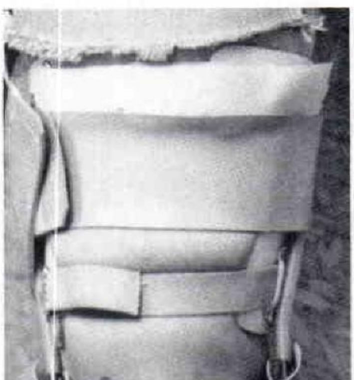


Figure 10. Anterior view of completed orthosis. Same patient as Figure 8.

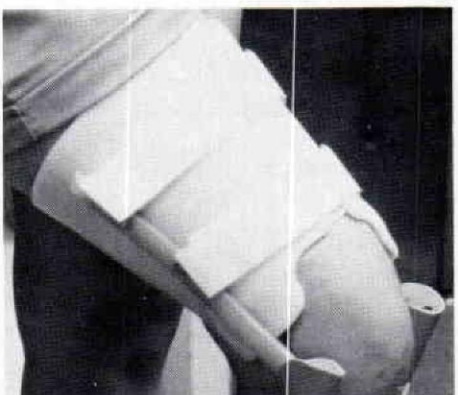


Figure 11. Lateral view of orthosis.

ing, while the plaster is setting, the medial supracondylar area is palpated and indented (see Figure 9).

The knee joint alignment is identified, a joint spacer is positioned, and the wrap is poured. After stripping the cast, the usual cast modifications are performed, with the exception of the medial supracondylar area. In this area, plaster removal is important, in order to obtain adequate pressure to suspend the orthosis. Good judgment and experience will aid in determining how much plaster is to be removed.

A PE-LITE liner is first molded on the cast. Best results have been achieved with 3 mm. A-20 firm density. Once this is completed, 3 mm. Subortholen is formed in two sections without vacuum. The leg and thigh sections are initially trimmed 3″ proximal and distal to knee center. The desired knee joints are then formed to the model, tongues of extra firm A-30 PE-LITE are molded, and the proper straps added. Figure 7 shows the various methods of placing the straps.

A slot (or slots) is cut as far distally in either the posterior-medial or posterior-lateral corner (or both if two straps are used) depending on which derotation strap is used. The distal end of the derotation strap exits through this slot and is secured to the outside of the Subortholen cuff with Velcro.® Before the uprights of the joints are riveted to the Subortholen cuffs they are covered with rubber surgical tubing for padding during athletic competition. Leather is used to cover the joint heads.

SUMMARY

As of late 1983, we had fit more than 100 TRIO Orthoses (Figures 10 & 11). Knee instabilities have been varying and for the most part, we have been able to control and prevent recurrent injury. Patient acceptance has been very good. However, the rotational strap may cause irritation initially and patients may complain of heat and pulling of the skin during wear. Irritation and pinching in the popliteal fossa are easily eliminated with an elastic knee support. The device is waterproof and therefore is readily cleaned with water. Being waterproof, there is no contraindication to snow or water skiing.

This new combination of material, joint system, and straps has aided us in the management of knee injury patients. We feel this orthotic device has provided better stability for athletes with knee instabilities when compared to other available knee orthoses today, as well as allowing early rehabilitation by protecting post-operative knees.

REFERENCES

[1] *Clinical Symposia*, Vol. 29, Number 1, 1977.

AUTHOR

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