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Knee Joint Materials and Components

by M.L. Stills, C.O.

The primary purpose of any orthotic knee joint, regardless of material or design, is to aid in providing stability to the patient's anatomical knee during loading of the extremity. In the paraplegic patient population, resistance to flexion of the knee is required during the periods of ground contact that occur during reciprocal gait. Orthotic knee joints can be used to provide medial-lateral control while permitting free flexion and extension, provide stance phase stability only during gait, or maintain locked knee extension during all phases of gait.

Materials used in the fabrication of knee joints for management of paraplegics are generally a hybrid of various metals, or in some cases, high-strength, reinforced composite plastics. Aluminum, and/or stainless steel machined preformed components, are common and can be considered state-of-the-art.

Mechanical knee joints are only a single component of a very complex system (Figures 1 and 2). How that component is incorporated into the entire system has an effect on the outcome of successful orthotic management. The success or failure of the entire orthotic system is dependent on many variables, i.e., accuracy of the original prescription, fabrication procedures, placement and alignment of mechanical joints relative to anatomical joints, lever arms, overall fit, training in the use of the orthosis, and the motivation of the patient.

FREE KNEE JOINTS

Free knee joints, having only hyperextension stops, are used to provide medial-lateral stability to the knee, or in situations when the patient has adequate extension power, but due to knee ligament laxity or muscle imbalance, is unable to control hyperextension.

Care must be taken when using free knee joints to check hyperextension. The orthotist must be assured that the patient has adequate voluntary muscle control to maintain knee extension. The orthosis may be required to permit a limited amount of hyperextension in order to provide stability during stance.

OFFSET KNEE JOINT

The purpose of the offset knee joint is to provide stance phase stability of the knee while permitting free knee flexion during swing phase. This should provide a more anatomical reciprocal type of gait and should reduce energy consumption.

The patient must have adequate voluntary muscle control to place the mechanical joint in a fully extended position and to move the ground reaction force anterior to the axis of rotation. The combination of ground reaction force, posteriorly offset orthotic knee joint, and a mechanical extension stop can provide stance phase stability for the paraplegic.

Many of the same factors that influence stability of the bilateral above-knee amputee also can be applied to the paraplegic patient using bilateral offset knee joints. Voluntary hip extension power is required. The use of crutches or assistive devices are almost always mandatory. Consideration must be given to the problems of uneven walking surfaces, changes in heel heights, and patient endurance. Dynamic extension assists are often added to this type joint, or an extension lock may be added and dropped into place when additional security is required.

LOCKED KNEE JOINTS

A locked knee joint (Figures 1 and 2) provides stability during the stance phase of gait and remains locked even during phases of non-ground contact. A mechanism is generally pro-

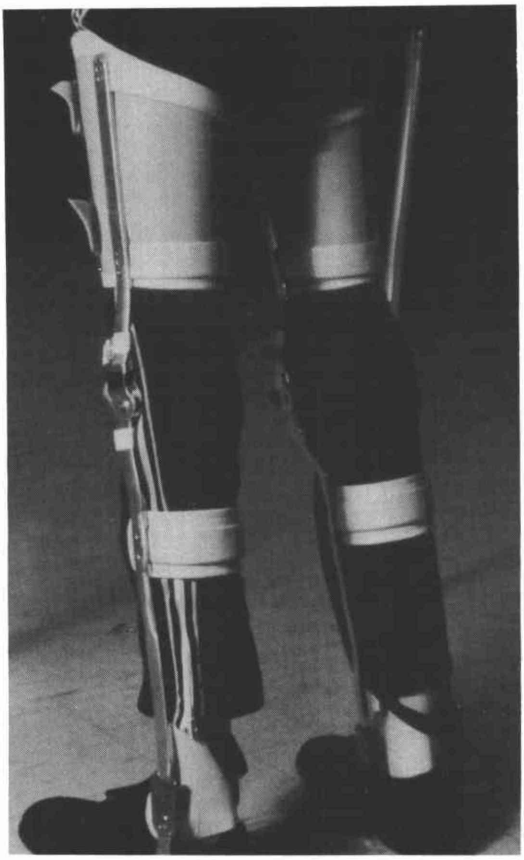

Figure 1. Conventional metal and leather bilateral knee-ankle-foot orthosis with single axis drop lock knee and double adjustable ankle joint.

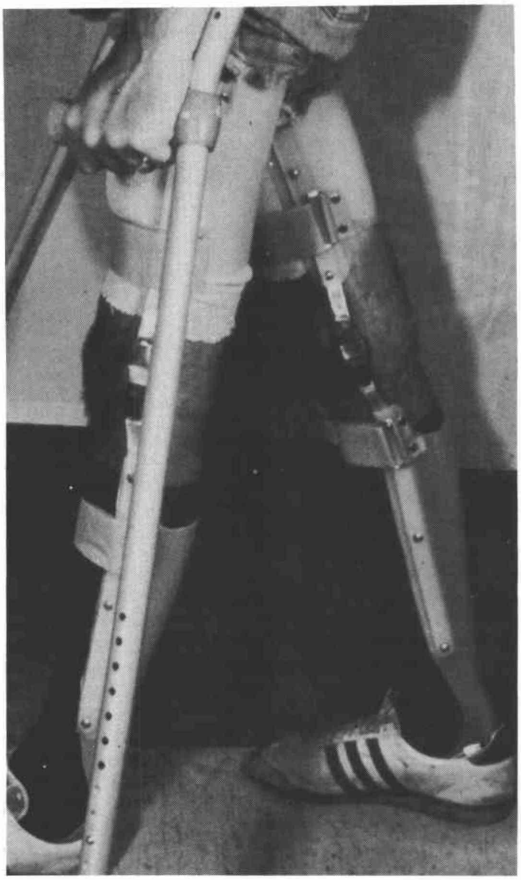

Figure 2. Bilateral polypropylene knee-ankle-foot orthosis with single axis drop lock knee and semi rigid ankle. FES was used with KAFO to facilitate swing through during gait.

vided to unlock the knee for cosmesis and comfort during sitting. Mechanisms for locking the knee joint in extension vary from simple gravity ring (drop) locks, spring-assisted drop locks, cams, pawls, and Swiss locks. Difficulty in unlocking the knee to permit sitting has led to the development of a variety of designs, again beginning with the simple ring lock, extensions added to drop locks, and bails (mechanical links between medial and lateral locks on a single extremity). To avoid accidentally unlocking a joint, designers have added ball retainers, springs, and elastic straps, all in an attempt to prevent accidental, unintentional flexion of the knee joint and subsequent falls and possible injury to the patient. There does not exist, however, a failsafe system that will completely eliminate the possibility of inadvertent knee flexion.

Solid knee orthoses have been used with limited success because of functional difficulties. Granted, the knee is stable during gait, but the inability to flex the knee during sitting makes the use of public and private transportation difficult and many times impossible. Social and public functions are difficult to manage when the user of a solid knee type device tries to sit and avoid blocking aisles or passageways. Difficulties related to a stiff knee have greatly reduced the use of surgical knee arthrodesis.

The use of medial and lateral components when fabricating knee-ankle-foot orthoses (KAFO) is commonplace. The use of such bilateral double upright construction certainly increases the weight of an orthosis and requires that the fabricator use techniques that insure both medial and lateral joint surfaces are absolutely parallel and in alignment with each other.

Nitschke in 1971 reported the results of using a single lateral upright in the fabrication of KAFOs. This technique reduced the weight of the KAFO and the problem of joint alignment.

Incorporation of knee joints into a conventional metal and leather type KAFO provides the orthotist with the option of adjustability and limited skin contact (Figure 1). Incorporation of knee joints into laminated and thermoformed KAFOs (Figure 2) provides a means for more intimate fit, better control of the extremity, improved cosmesis, and lighter weight, but limited adjustability in alignment and fit of the orthosis.

The Lower Extremity Telescoping Orthosis (LETOR) (Figure 3) incorporates a new concept in knee joints. It really does not have a knee joint, but a telescoping posterior rod that, when in its extended position, bridges the anatomical knee joint and does not permit knee flexion. By lowering the telescoping rod, knee flexion is permitted during sitting. This simple telescoping bar attachment and a solid ankle system provides knee stability in ambulation and becomes a valuable training system and may be used as a definitive orthosis for the limited household ambulator.

Other methods of controlling the knee joint externally must include the use of Functional Electrical Stimulation (Figure 2). These externally applied electrodes provide a means of electrically stimulating the muscles controlling the knee. Work has been done using electrical stimulation with and without forms of external knee support with mixed results. This work is still considered experimental, but there is every indication that it may become a means of providing control of the knee in the paraplegic population.

CONCLUSION

A number of knee joint designs exist. Those developed from metal, i.e., stainless steel and/ or aluminum, are best used when orthotically

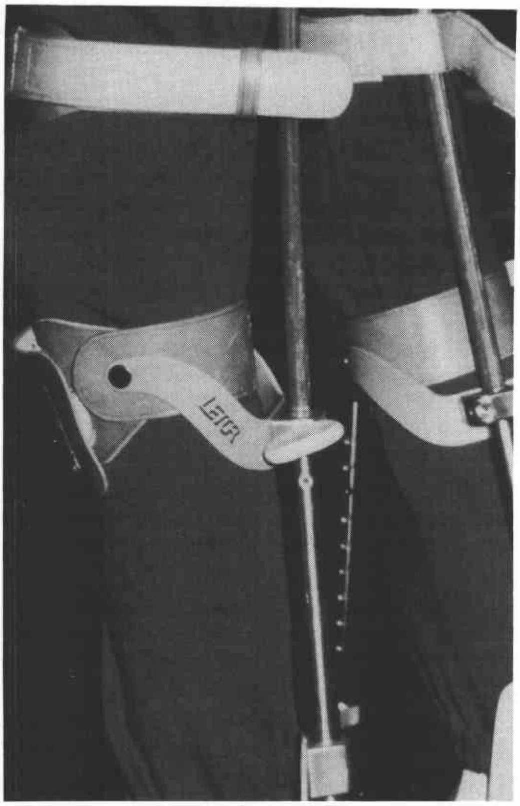

Figure 3. LETOR—Posterior telescoping rod bridges knee and prevents knee flexion.

managing the paraplegic patient. Thermoplastic knee joint designs can be used in the unilaterally involved patient or when the problem is related to structural instability and not voluntary muscle control.

Knee joints are made stable by including mechanical locks or stops, by alignment techniques to insure that the ground reaction force is anterior to the axis of rotation, or by the addition of springs, elastic straps, or cords that dynamically extend the knee.

Ground reaction forces can be combined with the paraplegic's own intact anatomical knee joint to provide knee extension without orthotic extension above the knee joint (Figure 4). This has been used with limited success in selected pediatric paraplegic patients.

Present and future research may drastically alter components and materials used in the future. At present, however, the combination of appropriate prescription, components, fabrica-

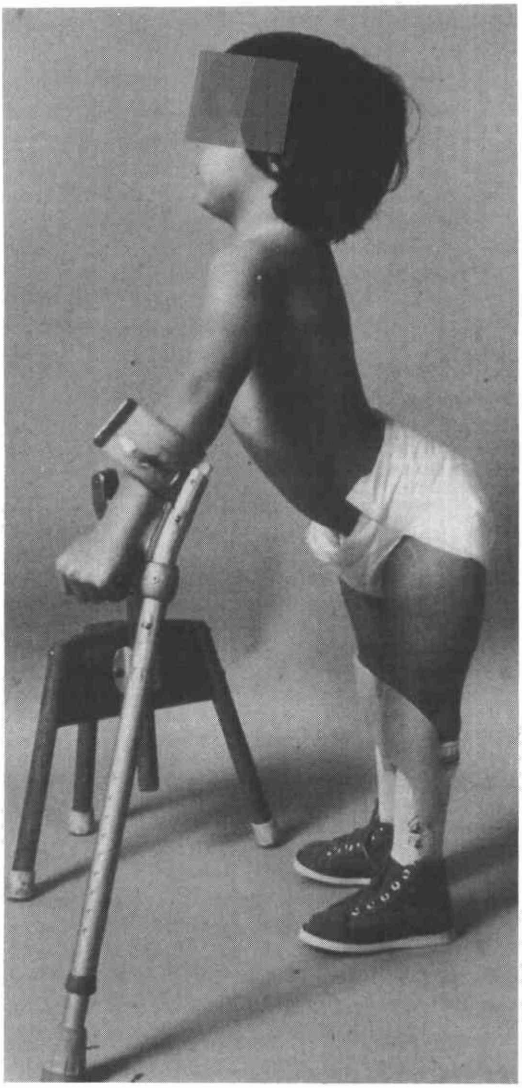

Figure 4. Floor reaction orthosis—posterior directed force on knee producing knee extension. Note hyperlordosis due to hip flexion contracture.

tion and fitting skills, along with skilled training in the use of an orthosis, will result in the potential for successful orthotic management of the paraplegic patient.

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