Orthotics and Prosthetics, Vol. 39, No. 2, pp. 61-64.

An Alternate System for Locking the KAFO Knee Joint: A Case Study

Locke Davis, C.P.O.

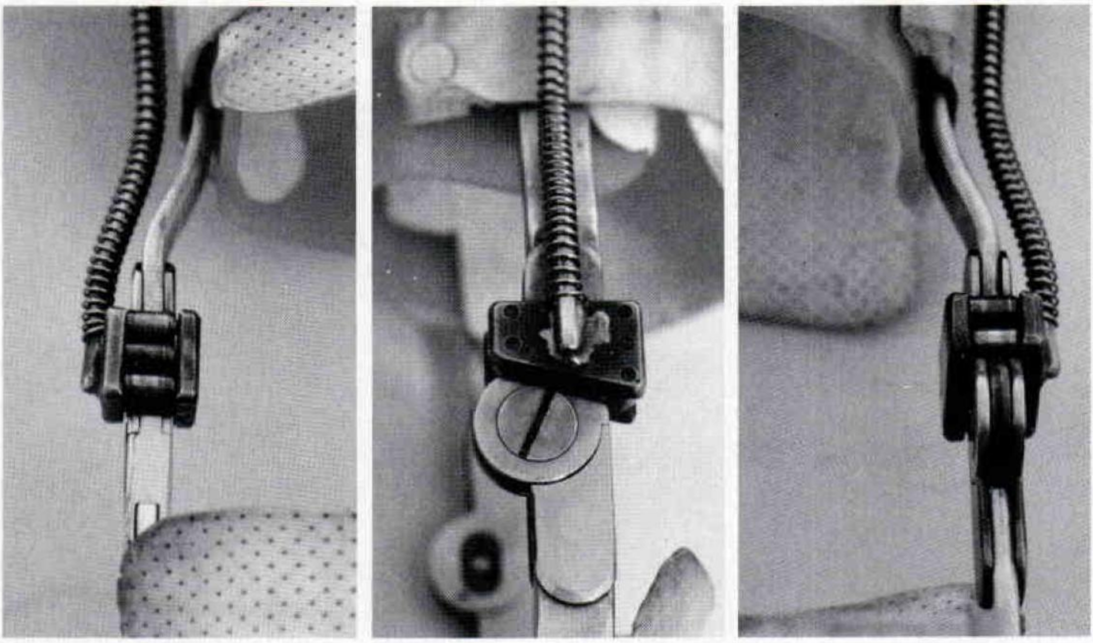
INTRODUCTION

The individual needs of patients requiring knee-ankle-foot orthoses with locked knee joints and the attempts of orthotists to meet these needs has yielded an array of devices all designed to accomplish a like goal: the voluntary locking and releasing of the orthotic knee joint. The commercially available locking mechanisms to date share the unfortunate characteristic of requiring an uncontrolled and often greater than desired amount of force to release the knee unit for flexion. Though many systems reduce the magnitude of force via a first or second class level system, or by pairing dissimilar surface materials between the lock and joint, the outcome often falls short of giving the wearer independent and spontaneous control of the orthosis.

The child who can't be constantly monitored by an adult and has no "helping hands" readily available to assist in the often difficult task of locking and unlocking the knee joints, will invariably encounter resistance in performing a daily routine. Therefore, an alternate design of knee lock that offers adequate stability when locked but requires a minimum effort to control can give the child using an orthosis a functional independence he might otherwise be denied.

DESCRIPTION OF THE SYSTEM

The knee joint locking system is composed of two steel plates bridged together by three anterior and two posterior one-eighth inch diameter steel dowel pins. Each pin serves as a shaft for a quarter inch diameter roller bearing made of hardened steel. Viewed in the frontal plane and in the locked position the Roller Bearing Drop Lock rests at the distal end of the proximal upright, just superior to the mechanical joint axis. The roller bearings are horizontal and the side plates appear vertical. An antero-superior section of the distal upright extends above the joint axis and serves as the lever arm for the two antero-distal roller bearings to rest against. The remaining antero-proximal bearing remains in contact with the anterior surface of the proximal upright, while the two



Figures 1, 2, and 3. Roller bearing drop lock. Figure 1: anterior view; Figure 2: lateral view; Figure 3: posterior view.

posterior bearings bridge across the posterior surface of the upright (Figures 1, 2 and 3).

RATIONALE FOR DESIGN

This design of drop lock provides an extremely stable locked position as the lever arm of the distal upright applies a horizontally directed force against the roller bearings which only travel vertically. When releasing the knee joint for flexion, the roller bearings greatly reduce the amount of resistance incurred by force applied through the lever arm. Due to the design of the roller bearing drop lock (R.B.D.L.), sliding friction is replaced by rolling friction where the anterior portions of the proximal and distal uprights and the posterior portion of the proximal upright have contact with the roller bearings. The advantage of such a system can be illustrated so:

$$F = \mu \times N$$

This fundamental equation expresses a relationship between the force required to move the drop lock (F) and the perpendicular force resisting motion (N). The Greek letter μ (mu) represents the coefficient of friction and is defined as the ratio:

$$\mu = \frac{F}{N}$$

The importance of this relationship becomes apparent when the averages for μ are given for sliding and rolling friction:

Sliding friction for steel
on steel 0.180
Rolling friction for bearing
on steel 0.002

and the forces at work are elucidated (Figure 4).

From this observation it becomes apparent that given any reasonable force N, the magnitude of force F to overpower the resistance is consistently reduced.

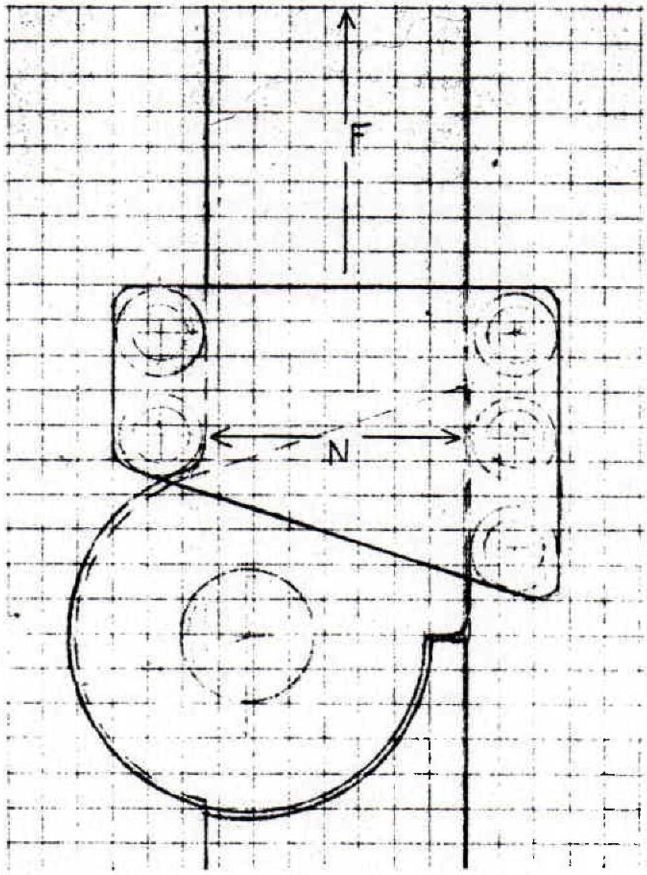


Figure 4. Schematic of roller bearing drop lock illustrating forces F and N and their respective vectors.

CASE STUDY

J.R. was diagnosed as having Duchenne's Muscular Dystrophy in 1981 at the age of four years. At this time he exhibited difficulty with gross and fine motor skills, a positive Gower's sign, and general clumsiness in his gait. There was no significant decrease in muscle strength until April, 1982 when he began to exhibit increased lordosis, decreased strength in the rotator cuff and in the hip muscle groups. These weaknesses were most evident when J.R. would rise from the floor to a standing position. He also walked with an externally rotated and abducted gait pattern. In October of 1983 J.R. began having difficulty ascending and descending steps. Both quadriceps were graded poor, and he appeared to exhibit some mild trunk instability. Grip evaluations were made with a Lamar Dynanometer. His left hand measured two pounds and his right hand measured three pounds grip strength.

Bilateral knee-ankle-foot orthoses (KAFO's) were prescribed in November of 1983 to aid and prolong J.R.'s ambulation. Each orthosis incorporated bilateral drop locks that were controlled by a connecting cable within a housing. The cable housings ran vertically up the medial and lateral uprights where the cable was exposed across the anterior aspect of the thigh. Pulling up on the cable elevated the drop locks and allowed knee flexion. This system posed a functional difficulty for J.R. because of his grip strength and precarious trunk balance. Later, the grip mechanisms were modified, but the strength required to operate the locks still denied J.R. the convenience of independent function. A single roller bearing was tried on each anterodistal section of the drop locks and he was able to control this locking system, but intermittent binding continued to occur.

In 1984 new orthoses were prescribed due to growth, and a more radical approach to reducing the amount of strength required to control the knee joints was decided upon, so the RBDLs were incorporated in the orthoses. To date, J.R. has exhibited complete autonomy in locking and unlocking his KAFO's. There is no longer any doubt of whether his knee lock will release this time.

SUMMARY

This paper presents a typical problem encountered by orthotists who have a great deal of exposure in pediatric orthotics. Conventional knee locking systems often require highly variable amounts of strength to operate successfully on a daily basis. Many children (and some adults) do not possess the strength or adroitness to deal with these unpredictable and often stressful lock systems. Such problems can be avoided in orthotics, and doing so can offer the child using an orthosis a greater autonomy, and reduce the stress and frustration associated with extensive bracing.

AUTHOR

Locke, Davis, C.P.O., is Manager, Applied Orthopedics, Inc., 434 N. Lorraine, Wichita, Kansas 67214.

BIBLIOGRAPHY

Gribbins, Maureen, R.P.T., Woodman Elementary School, Wichita, Kansas.

Rush, J. David, Roller Bearing Drop Lock-concept and design.

White, H.E., D.H. White, and M. Gould, *Physics–An Experimental Science*, Van Nostrand Co. Inc., 1968.