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Design and Development of Dynamic Metatarsophalangeal Joint Plantar Flexion Assist Splint for Subject with Dorsal Foot Burn

Akankshee Maurya[1], Srishti Singh[2], Raj Kamal[3], Anupriya Tripathi[4], Kumarpal Singh[5], Gargi Khare[6,7], Sthir Prajyan Biswal[7], Rohina Kumari[8]

[1]BPO Intern, Department of Prosthetics and Orthotics, Dr. Shakuntala Misra National Rehabilitation University, Lucknow, Uttar Pradesh
[2,3,4]Demonstrator, Department of Prosthetics and Orthotics, Dr. Shakuntala Misra National Rehabilitation University, Lucknow, Uttar Pradesh
[5,6,7]Assistant Professor, Department of Prosthetics and Orthotics, Dr. Shakuntala Misra National Rehabilitation University, Lucknow, Uttar Pradesh
[8]Orthotist, Artificial Limb and Rehabilitation Centre, Dr. Shakuntala Misra National Rehabilitation University, Lucknow, Uttar Pradesh

Corresponding Author: Srishti Singh

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ABSTRACT

People with burn injuries will unavoidably develop contracture if orthoses are not used. Range of motion is restricted in these patients because of the scarred tissues shortening. Using dynamic foot orthoses to maintain proper position is now essential and helpful in preventing contracture and achieving early range of motion in dorsal foot burn. The aim of this research is to develop a Dynamic Metatarsophalangeal planter flexion assist splint that permits plantarflexion of the foot while avoiding dorsal foot contracture.

Keywords: Metatarsophalangeal Joint, Planter flexion, Dorsal Foot Burn, Contracture, Orthosis, Ankle foot orthosis.

INTRODUCTION

An incidence of fifteen-foot burn injuries annually was previously described, as was the epidemiology of isolated foot burns. Foot burns affect a specific part of the body and can result in a high level of morbidity while only affecting 3.5% of the body's surface. The reason for this is that foot burns frequently necessitate extended bed rest. The length of hospitalization, the time lost from work, and the increased risk of complications come at a tremendous financial and emotional cost to the person.[1]

The degree of burn on the foot determines how it should be treated. The literature recommends several daily dressings with close monitoring, splinting of the foot, early bed rest and elevation for up to three days to control oedema, pain management for superficial partial thickness burns, and frequently used topical antibiotics, which are typically used as part of the dressings and frequently prophylactic systemic antibiotics. If superficial partial thickness foot burns are aggressively managed to avoid infection, they may not proceed into deep partial thickness burns, which are known to happen when an infection is present.[2,3]

Dynamic splinting has been used extensively as a strengthening tool to allow MTP joint

movement, stretch muscles, and preserve the foot's normal alignment while the patient is on bed rest. In order to prevent dorsal foot contracture in patients with dorsal foot burn while allowing for plantarflexion of the foot, the current study set out to design and construct a Dynamic Metatarsophalangeal planter flexion assist orthosis.

MATERIALS AND METHODS

Subjects

The study was conducted from August 2023 to July 2024 at ALRC, DSMNRU in Lucknow. Participants with dorsal involvement and second-degree foot burn who were between the ages of 5 and 50 were included. The study excluded participants with severe MTP joint contracture, metatarsal head fractures, and open wounds on the heel or dorsal side of the foot. The participants were asked to participate in the research. The subjects were assessed and screened in accordance with the inclusion criteria. The subjects were given a detailed explanation of the process. The consent form was signed by study participants who consented to take part. A 14-year-old male subject was chosen based on the inclusion criteria.

METHODOLOGY

The dynamic metatarsophalangeal joint plantarflexion assist splint was fabricated from the following components, such as: Ankle Foot Orthosis (SAFO), T shape Aluminium bar, Spring (fig.1), Calf strap, mid strap, outrigger (fig.2) and splint with patient (fig.3).

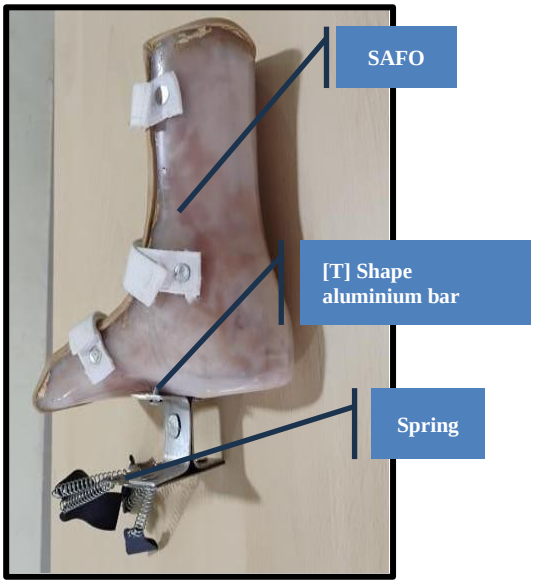

Fig.1 Side view

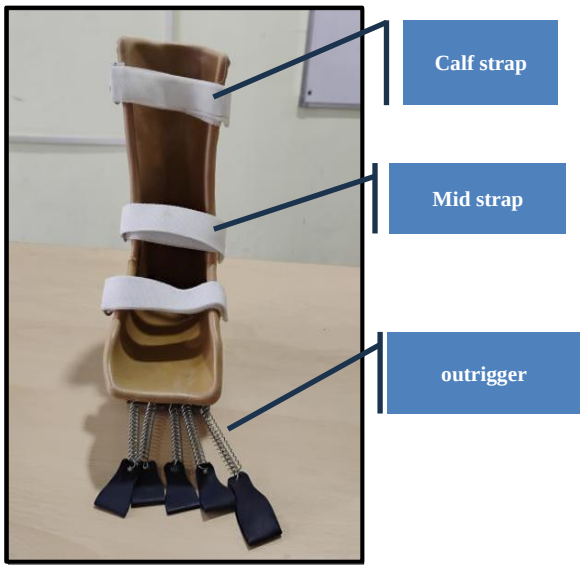

Fig.2 Front View

Fig. 3 Dynamic MTP PF Assist splint with patient

The outriggers will be positioned distally to the midfoot area, perpendicular to the MTP joint. To prevent toe contracture, leather loops and springs will be positioned to pull the

toes in plantarflexion. The straps will apply force to keep the foot in the correct position.

BIOMECHANICS OF DYNAMIC MTP PLANTARFLEXION ASSIST SPLINT

Applying a moving force compartment that stays roughly constant while the part moves is known as dynamic splinting. By pulling on rubber bands and separate slings, the strategically positioned outriggers generate a direction of force for traction. To be more precise, the outrigger acts as the dynamic splint's pivot. When help gaining passive range of motion is required, these splints are used. The following factors should be taken into account while designing a dynamic splint:

1. **Provides resistance:** For example, an outrigger positioned on plantar side of foot and equipped with rubber-band traction can offer regulated resistance to the dorsiflexors, preserving tendon glide and reducing adhesion issues. By improving fluid dynamics and reducing edema, the pumping action created by the dorsiflexors contraction and relaxation against the resistance of the rubber band can be beneficial. Using it can also help build stronger muscles.
2. **Prolongs stretching:** Stiff joints and shortened musculotendinous units will be stretched with the aid of the dynamic splint design. For a long time, it gives the tissue passive traction, which is a regulated, prolonged, mild stretch. The dynamic splint must move what the person is unable to. The tension and stretch should be felt by the patient, but the pull shouldn't hurt. For extended stretching, it is equally crucial how much strain is placed on the joint and how long the patient may wear the splint. Brand recommends applying 200–250 g of force for long-term, moderate stretching.
3. **Substitution:** For patients with weak or absent plantar flexors, a plantar side positioned outrigger can help or replace them.[4,5]

Always maintain the 90-degree line of pull. The outrigger's location must adjust in tandem with the contracture's alteration. The long bone, which is the distal articulation to the limited joint, has an axis perpendicular to the 90-degree line of pull. The involved joint experiences an undesired pulling force when a force greater than 90 degrees is applied, while the articular surface experiences a pushing force when a force less than 90 degrees is applied.[4,6,7]

RESULT & DISCUSSION

The current study's findings indicated that patients with dorsal foot burn found that the dynamic MTP splint with plantarflexion assist was a successful treatment option. The splint provides the ideal stress for scar tissue lengthening to achieve range of motion by combining low load force with long-lasting holding.

These findings were consistent with those of William S. Dewey et al., who found in their study that positioning and splinting are essential components of a complete burn rehabilitation program that focuses on contracture avoidance. The emphasis on splinting during the rehabilitation process to match the varied demands of individuals with burn injuries. To successfully manage burn scar contracture, positioning devices and splints should be used early, effectively and consistently.[8]

Suzanne G. et al. state that the static progressive splint placed during non-ambulatory times should give a low-load, long-duration stretch that is gradual and adjustable by the patient to maximize comfort and, consequently, compliance.[9]

In order to prevent deforming scar contractures from dorsal foot burns, Salma S. E. et al. created a static splint that provides regulated tension and prolonged stretch. A piece of aluminium metal at the foot base and elastic bands attached to brackets fastened to the nails were used in the design of the splint to stretch the toes as much as possible into a neutral position.[10]

The Dynamic Metatarsophalangeal plantarflexion assist splint has been utilized extensively as a strengthening tool to allow the metatarsophalangeal joint to move while the patient is on bed rest, stretch the muscles,

and maintain the correct foot position.

CONCLUSION

Dorsal foot burn can be effectively treated with a low-cost, light-weight, and dynamic MTP plantarflexion assist splint. The study's findings indicated that utilizing a dynamic MTP plantarflexion assist splint resulted in a statistically significant reduction in contracture and improvement in range of motion. Consequently, it can be concluded that the dynamic MTP plantarflexion assist splint is a useful orthosis for treating dorsal foot burn. To generalize this study, however, additional analysis involving a larger patient population and longer follow-up is required.

Declaration by Authors

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