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Syme's Amputation: Challenges and Choices

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Abstract: ***Syme's amputation presents significant challenges in prosthetic fitment, often limiting mobility and functional outcomes. To address these challenges, a novel prosthetic foot has been developed at MGM Institute's University Department of Prosthetics and Orthotics, Kamothe, Navi Mumbai. This innovative design integrates a toe - break mechanism and an energy - restoring spring system, aiming to replicate the natural gait cycle by facilitating a smooth heel - to - toe transition. A clinical case of a Syme's amputee was successfully managed using this prosthetic foot, resulting in enhanced mobility and improved performance in daily activities. The advanced biomechanical design minimizes energy expenditure while optimizing gait efficiency, offering an effective and accessible solution for individuals with Syme's amputation.***

Keywords: Prosthetic Foot, Syme's Amputation, Toe - Break Mechanism, Energy Restoration, Gait Optimization

1. Introduction

Over the years, the field of Prosthetics and Orthotics has evolved significantly, serving a diverse range of patients with varying diagnoses. By integrating advanced medical and engineering concepts, the discipline continues to expand its horizons, fostering innovation and technological advancements. As part of this ongoing progress, a novel solution has been developed to enhance mobility for individuals with Syme's amputation— a prosthetic foot incorporating helical springs to mimic a toe - break mechanism.

This specialized prosthetic foot is designed to facilitate a more natural gait by replicating the toe - break mechanism, thereby ensuring a smoother, fuller gait cycle. The prosthetic system consists of an Syme's Prosthesis featuring a Patella Tendon Bearing Supracondylar (PTBSC) socket lined with "Evazote, a soft material". The helical spring - integrated prosthetic foot is then attached, enabling the amputee to achieve improved biomechanical efficiency while walking.

The primary objective of this innovation is to optimize energy expenditure for individuals with Syme's amputation. By incorporating a spring - based energy storage and release system, the prosthesis aims to restore lost energy during ambulation, thereby enhancing mobility and reducing physical exertion. Additionally, the design focuses on cost - effectiveness, ensuring accessibility while maintaining optimal functionality and durability. This advancement represents a step forward in prosthetic rehabilitation, offering an efficient and affordable solution for enhanced mobility and quality of life.

Indications

Syme's amputation patients
Basic components
Anatomical design
The prosthetic foot mimics the natural anatomical movement of the foot including the toe break.

Spring mechanism
position of the spring to enhance toe break which replicates the biomechanics of natural gait.

Energy storage
The spring mechanism efficiently stores and releases energy during the gait cycle, improving the efficiency of ambulation. A biomechanical design that allows controlled energy release during different phases of walking.

Materials selected for fabrication which is durable and cost effective to ensure a longer lifespan for the prosthetic foot.

Problems Faced in the Symes Amputation.
- Disturbs the alignment
- Support
- Load bearing
- Cosmesis
- Affects the symmetry of gait.

Clinical Challenges in Syme's Amputation
- Height adjustments
- End bulbous stump
- Donning and doffing is an issue
- Lack of cosmesis
- The longer stump limits fitting options to secure the foot within the socket.

Principles of Syme's Amputation.
Syme's amputation is a surgical procedure where the foot is removed at the ankle joint.

2. Case Study No. 1

A 12 - year - old boy was referred to the Department of Prosthetics & Orthotics at MGM Hospital, Kamothe, Navi Mumbai, following a Syme's amputation performed one year ago due to a road traffic accident. At the time of referral, he was unable to ambulate independently and relied on a walker for mobility, remaining dependent on others for basic activities of daily living (ADLs).

Clinical observation revealed a limping gait and an inability to walk without assistive devices. Additionally, the limited residual limb space posed a challenge in fitting commercially available prosthetic feet.

To address these challenges, a customized prosthetic solution was developed, consisting of a specially designed Syme's prosthetic foot integrated with a well - fitted socket. Following the fitment, the patient demonstrated significant improvements in mobility, with no limb length discrepancy (LLD), ensuring proper gait alignment. Initially, ambulation training was provided using a walker, followed by a transition to a tripod stick. Eventually, the patient achieved independent walking without any assistive aids.

This facilitated smoother gait transitions, boosting walking speed and energy efficiency, attributed to the prosthetic foot's toe - break mechanism, which facilitated smoother gait transitions and enhanced energy restoration. This customized intervention not only restored independent mobility but also significantly improved the patient’s overall quality of life.

3. Case Study No. 2

A 43 - year - old male was referred to the Department of Prosthetics & Orthotics at MGM Hospital, Kamothe, Navi Mumbai, following a Syme’s amputation performed three years ago due to a road traffic accident. At the time of referral, the patient was using a conventional prosthesis that resulted in a limb length discrepancy (LLD) and an associated limping gait.

Clinical evaluation confirmed the presence of a limping gait with the conventional prosthesis, affecting overall mobility and functional independence.

To address these challenges, a customized socket was fabricated and integrated with a specially designed prosthetic foot. The newly designed prosthesis effectively eliminated the limb length discrepancy, ensuring proper alignment and improved gait mechanics. Following the fitment, the patient demonstrated significant enhancements in mobility.

Initially, ambulation training was provided using a walker, followed by a transition to a tripod stick. Over time, the patient successfully achieved independent walking without assistive devices. The incorporation of a toe - break mechanism in the prosthetic foot further contributed to increased walking speed and improved energy efficiency, facilitating a more natural and biomechanically efficient gait.

This intervention not only restored independent mobility but also significantly enhanced the patient’s overall quality of life by enabling greater functional independence in daily activities.

4. Methodology

Fabrication of Syme's Prosthesis
Accurate measurements of both the amputated and sound limb are essential to ensure precise prosthetic modifications and optimal alignment.

A thorough stump assessment must be conducted prior to initiating the casting process. The casting procedure follows Fillauer's technique three - stage technique to fabricate a Patella Tendon Bearing Supracondylar (PTBSC) socket. The primary objective is to create a positively modified mold that replicates the inner contours of the socket. During this process, excess plaster is removed from pressure - tolerant areas, while additional plaster is added to pressure - sensitive regions to enhance patient comfort and prosthetic fit. The final mold measurements are carefully verified for accuracy.

The fabrication of the soft socket involves the use of Evazote material for enhanced cushioning and comfort. A negative mold is then prepared for the draping process, in which a polypropylene sheet of 10mm or 12mm thickness (depending on the patient's age and weight) is precisely cut according to the below - knee (BK) frame specifications.

Once adequately heated, the polypropylene sheet is draped over the mold, with suction applied to ensure proper contouring. Upon completion of this process, the hard socket is finalized, providing a durable and well - fitted prosthetic interface for the patient.

Inventions & Innovations
The prosthetic foot is designed with an anatomical structure that closely mimics natural movement, incorporating a toe - break mechanism to enhance gait fluidity.

A specialized spring mechanism is integrated to further optimize the toe - break function, contributing to a more natural walking experience. This mechanism efficiently stores and releases energy, enhancing overall mobility and reducing the metabolic cost of ambulation.

Biomechanical design ensures controlled energy release throughout different phases of the gait cycle, promoting stability and efficiency. Constructed from durable and cost - effective materials, the prosthesis offers both longevity and accessibility, making it a practical solution for users.

Benefits of the Project
The designed prosthetic foot is lightweight and can be custom - made to accommodate any size, ensuring a tailored fit for each user.

The integrated spring mechanism replicates the natural anatomical movement of the foot, including the toe - break function, which is not commonly available in most commercially marketed prosthetic feet. To enhance durability and functionality, the design incorporates three springs. In the event of a spring malfunction or breakage, the amputee can continue using the foot, as the remaining springs maintain stability. Additionally, the springs can be repaired or replaced as needed, ensuring long - term usability.

5. Conclusion

The designed prosthetic foot effectively replicates natural anatomical foot movements through a spring - based mechanism while minimizing energy expenditure. It offers an affordable, lightweight, and low - maintenance solution, providing a toe - break mechanism that enhances gait efficiency. This energy - efficient innovation empowers amputees with a more natural walking experience and improved accessibility.

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Conflict of Interest: None

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