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Comparison the Posterior Shell and Posterior Leaf Spring Socket Design for Syme's Amputee in Terms of Normal Gait Kinematics: Case Study

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Abstract

Background: Syme's amputee patient commonly walks on the distal end of the stump. Two types of sockets are commonly prescribed to these patients: Syme sockets with either complete posterior shell or leaf spring design. The purpose of this kinematic study was to compare the effectiveness of both these socket designs in terms of different gait variables. **Methods:** The study design was a case study, therefore, only a single Syme's amputee was selected for data collection. Both posterior shell and posterior leaf spring sockets were made for the study participant. The study participant was given the opportunity to use each socket for 15 days before data collection in the 2D gait analysis lab. The data was compared with normal gait values, so the socket which had gait parameter values was closer to the normal gait kinematic values. That was considered as the most effective socket. **Results:** The results of this study showed that the posterior leaf spring socket design has closer to normal Stance phase (62%) as compared to complete posterior shell design (65%). Similarly, the values of swing phase were 38% for leaf spring design and 35% for posterior shell design which clearly indicate that the posterior leaf spring socket design is more effective than posterior shell socket design.

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Introduction

The partial foot amputee continues to bear weight on the residual foot in a manner which approximates the normal in regard to the proprioceptive feedback as opposed to the below knee level in which an entirely new feedback pattern must to be interpreted. The majority of adult onset diabetics with peripheral neuropathy also restrain sensation in the arch and heel area [1].

Full weight bearing on the heel pad normally channeled proprioceptive feedback is what distinguishes the syme's amputation below knee amputation. The key success in Syme's amputation is meticulous surgery to preserve the Syme's unique characteristics and maintenance of weight bearing heel pad in a centralized position. Since the heel pad is dependent on the posterior tibial artery for its blood supply or other means is recommended in order to reduce the chance of failure to 20% or less. Meticulous surgical technique is required to avoid damage to the posterior tibial artery and to its vertically oriented, fat filled chamber of the heel pad, which provide the cushioning, allowing comfortable and long lasting end bearing [2].

In this study we will compare the effectiveness of posterior shell socket as compared to posterior leaf spring socket in terms of normal gait kinematics by evaluating how long the patient could bear the weight on his device (time phase during stance).

Methods

A single case study design that consisted of a syme's amputee male patient. A convenience sampling technique was used for patient selection. Patients were selected from PRSP Peshawar rehabilitation Centre (PIPOS). Patients were thoroughly accessed for this study before conducting the study and the consent form was filled from the guardian of the patient. This study was conducted in PIPOS Peshawar and the duration of this study was 6 months. The parameter used in this study was time phase (%) during one gait cycle in stance and swing.

Results

Table 1 shows the gait parameters in both the gait phases of actual, normal and deviated gait while the patient was barefoot, using PFP with posterior shell, and posterior leaf spring designs. In the stance phase the actual value in barefoot is 61.42%. The posterior shell stance phase value is 65.44% and the posterior Leaf spring stance phase is 62.88%. In the swing phase the actual value in barefoot is 38.58%. The posterior shell value is 34.56% and the posterior leaf spring value is 37.12%.

Table 1. *Differences between PLS and p.Shell socket design*

Gait parameters	**Actual (%)**	**Normal (%)**	**Deviation (%)**				
	Bare Foot	PS	PLS		Bare Foot	PS	PLS
St phase (%)	61	65	62	**60**	1	5	2
Sw phase (%)	38	35	38	**40**	-2	5	-2

While in case of the deviated gait the parameters during stance phase in bare foot is 1.42%. The posterior shell value is 5.44% and the value of posterior leaf spring is 2.88%. In the swing phase the deviated values in bare foot is -1.42%, posterior shell value is -5.44% and the value of posterior leaf spring is -2.88%. This shows that the posterior leaf spring has values that are almost near to the normal gait parameters.

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In table 2, the actual gait value in barefoot at hip joint is 31.42%, the knee joint value is 35.21 and ankle value is 0.00.while in case of the deviated value of hip -18.58, knee joint -35.21 and ankle -30.The actual gait value in posterior shell socket design at hip 44.78, knee joint value is 62.19 and ankle joint value is 17.37.while in case of the deviated value of hip joint -5.22, knee joint value is -7.81 and ankle joint value of -12.66.The actual gait in posterior leaf spring socket design at hip joint 39.44, knee joint value is 62.03 and ankle value is 18.93.while in case of the deviated value at hip joint -10.56,knee joint value of -7.97 and ankle joint value of -11.07

Table2. Range of Motions in both the gait phases of actual, normal and deviated gait with bare foot, posterior shell and the posterior leaf spring.

Gait parameters	**Actual (%)**	**Normal (%)**	**Deviation (%)**				
	Bare Foot	PS	PLS		Bare Foot	PS	PLS
St (%)	61	65	62	**60**	1	5	2
Sw (%)	38	35	38	**40**	-2	5	-2

Discussion

The objective of this study was to evaluate the effectiveness of posterior shell socket design and posterior leaf spring socket design on the normal gait value in syme's patients. Our result shows that there is a difference in stance phase and swing phase in posterior shell socket design but in patient the posterior leaf spring socket design gives more real result stance phase 62% and swing phase 38% of knee compared with posterior shell socket design stance phase 65% and swing phase 35% and with shoe stance phase 61% and swing phase 39%.

The posterior leaf spring socket design gives more appropriate values in the stance phase 62 % and the value of initial contact is 0° at trunk, 24° at hip, 23° at knee and 1° at ankle. Now if we talk about foot flat the value of trunk is 5°, hip 20°, knee 24° and -8°. Moving toward midstance the trunk is at 0°, hip is at 7°, knee is at 17° and ankle have 5° than at the terminal stance the trunk at -8°, hip -4°, at knee 31° and at the ankle 2° than the toe off at the trunk -6°, at hip 1°, knee 46° and at the ankle 10°

In the Swing phase 38 % and the value of initial swing and the value of initial swing at the trunk -4°, at the hip 9°, at the knee 66 and at the ankle 4° than at the midswing the value of trunk 0°, at the hip 27°, at the knee 64° and at the ankle 4° than at the terminal swing at the trunk 1°, at hip 31°, at the knee 31° and at the ankle value is 10°

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Conclusion and Recommendation

It was an experimental study design which compared the effectiveness of two partial foot socket designs for syme's amputee patient: the posterior shell socket design and posterior leaf spring socket design. In syme's amputee patient in terms of normal gait kinematics in gait cycle. Study consists of three trials in which the patient walked in gait lab with bare foot, posterior shell socket design and with posterior

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leaf spring socket design. Data was assessed in the gait lab and the graphs were made in excel software. The resultant data was compared with the normal value of the gait cycle. According to the results the posterior leaf spring socket design is more effective than posterior shell socket design in keeping the trunk, hip, knee, and ankle joint in minimum difference with normal gait Kinematics angles of the above mentioned joint at the stance and swing phase events and also improve the stance and swing phase of the gait cycle.

Basically we faced three main limitations in our study. First limitation may also come due to major factors such as covid19 pandemic. secondly was that our study was not under a highly controlled system in terms of extra technical skill, in fabrication, gait lab operating skills and due to an expert team. Thirdly our study included only two patients that we cannot apply the result to a large population. Show in three tables' trunk, hip, knee and ankle. It's all bold kinematic values that compare both socket designs.

It is advised that the research should be carried out in a well-controlled setting with the assistance of a skilled team so that the outcome will be more exact and accurate if patients are followed up in the future. There will be more than one group in this study. Future comparisons should be made between the anterior shell socket design and the same posterior leaf spring socket data.

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