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Development of Shuttle Lock Suspension System for Transtibial Prosthetic Users

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Abstract

A well-designed prosthetic suspension system is essential for keeping the residual limb securely inside the prosthetic socket. It greatly affects the mobility and satisfaction of amputees. Although many suspension systems are available for transtibial amputees but expensive. To create and test a locally-made Shuttle Lock suspension system that is more affordable. An experimental study was conducted to evaluate the performance of the newly developed Shuttle Lock suspension system made locally. The locally-made Shuttle Lock suspension system was well-received by users, providing a comfortable, secure, and durable solution for transtibial prosthesis users. The shuttle lock suspension system covers the residual limb and the prosthetic socket to provide a lock and secure system that is easy to use, although areas of difficulty which included misalignment and pressure concerns were noted, they were small compared to the fact that it was easy to put on and take off.

Keywords: Shuttle Lock, Residual Limb, Suspension, Adjustability, Comfort

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Contents

- [Introduction](#)
- [Working Mechanism](#)
- [Shuttle Lock Mechanism](#)
- [Comfort of Shuttle Lock Suspension Systems](#)
- [Benefits of the Shuttle Lock System](#)
- [Clinical Considerations](#)
- [Materials and Methods:](#)
- [Selection Criteria:](#)
- [Summary of Findings](#)
- [References](#)

Abstract

A well-designed prosthetic suspension system is essential for keeping the residual limb securely inside the prosthetic socket. It greatly affects the mobility and satisfaction of amputees. Although many suspension systems are available for transtibial amputees but expensive. To create and test a locally-made Shuttle Lock suspension system that is more affordable. An experimental study was conducted to evaluate the performance of the newly developed Shuttle Lock suspension system made locally. The locally-made Shuttle Lock suspension system was well-received by users, providing a comfortable, secure, and durable solution for transtibial prosthesis users. The shuttle lock suspension system covers the residual limb and the prosthetic socket to provide a lock and secure system that is easy to use, although areas of difficulty which included misalignment and pressure concern were noted, they were small compared to the fact that it was easy to put on and take off.

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Introduction**Context and Relevance**

Persons with disability are many in society and they struggle in such aspects as education, employment, health, and social engagement

among others. All these challenges translate to high risk especially when compounded by stigma and discrimination. In this case, various reforms have proposed improvements in the ease of access and rights of women but many societies are not yet able to furnish the required



support and opportunities to them. To solve these problems, it is necessary to employ approaches based on facilitating access, supporting independent living of persons with disabilities, and creating a disability-friendly environment in all spheres of life. Therefore, as we continue to educate others, and provide equal policies and support for the rights of the disabled, the world will be a more accepting place.

The Shuttle Lock Suspension System

Another essential solution is the Shuttle Lock suspension system whereby the function of artificial limbs could be enhanced. This attaches the prosthetic socket to the remaining part of the limb in a very secure manner. It normally employs a pin system that fits in a complementary piece on the liner or directly on the limb. The Shuttle Lock provides a good seal, which provides the user with security and minimizes the chance of the prosthesis sliding during motion. This will enhance the comfort and confidence of the user in handling the machinery.

Importance of Suspension Systems in Prosthetics

Prosthetic limbs are important for the physically disabled, especially for those who have undergone a transtibial amputation which involves the removal of the limb below the knee. Satisfaction concerning the prosthetic limb is mainly based on its fit and security which determine the comfort and operations of the affected limb. In suspension systems, the most common systems that are recognized for their efficiency are called the Shuttle Lock system. They enable secure attachment and the Prosthetic Interface can be fitted with various prosthetic socket design forms and liners for each individual.

Components and Mechanism of the Shuttle Lock System

As stated earlier, the most commonly used suspension system in the Shuttle Locks is as follows:

1. Prosthetic Socket: This is the part of a prosthesis that covers the remaining limb amputee that still exists on the stumped person.

Shuttle Lock Mechanism

1. Shuttle Lock Mechanism: This comprises an easily retractable pin or plunger that protrudes from the socket and locks into a corresponding feature on the liner or directly on the residual limb.
2. Liner: It is a soft cover which is usually in silicone or gel form, which is worn over the residual limb to provide cushioning and to assist in engagement with the shuttle lock mechanism.
3. Receptacle: This part is connected with the shuttle lock mechanism and may be incorporated into the liner or can be screwed onto the limb thus securely gripping the pin or the plunger in the socket.
4. Retention Sleeve (Optional): There is always an additional sleeve that encloses and shields the shuttle lock mechanism making it harder and easier to operate.

Working Mechanism

1. Insertion: The residual limb of the amputee gets into the prosthetic socket as it has been designed and fitted well to give a firm hold on it.
2. Engagement: The shuttle lock mechanism, so in most cases in the shape of a pin or a plunger, fits into the relevant aperture on the liner or the limb.
3. Alignment and Locking: They of right confirmation that the pin or the plunger is

in the correct position to lock into the right receptacle and there is no slippage.

4. **Secure Connection:** The pin or plunger enables them to fit well in the slot of the socket as well as in the limb.
5. **Weight Distribution:** The system is able to offload weight from the limb to the prosthetic socket as it assists with stability and balance.
6. **Comfort and Function:** Since using the present shuttle lock system to securely grip the socket, comfort is enshrouded and people can perform movements and activities.

The design and working of the Shuttle Lock system are quite similar to the lock which is in the badminton shuttlecock. Because of its ease of use and dependability; it has garnered popularity for transtibial or below-knee amputations especially where the sturdiness of connection and lightness are critical for physical therapy and mobility.

Comparison with Other Suspension Methods

In addition to the Shuttle Lock system, other suspension methods include:

1. **Waist Belt:** A strap that is tightly secured on one side to the top edge of the socket. Some of the users have a complaint that it feels a bit uneasy when put under the clothes, but it secures suspension well.
2. **Cuff:** There is another cuff called the supracondylar cuff which is fixed to the socket while the other side of the cuff hangs on the patella. The shoe is suitable for persons with vascular complications or scarring yet the stumped or those with knee ligament troubles may not benefit from it.
3. **Thigh Lacer and Corset:** They include a thigh lacer with metal side joints and a thigh corset in case of added support though they may be uncomfortable or practically useful for some persons.

Thus, each prosthetic device has advantages and disadvantages and the choice of suspension system is one of the critical parameters that define how well the prosthesis performs and how comfortable the user feels.

Literature Review: Evolution of Suspension Systems in Prosthetics: Introduction

The suspension system is an important aspect in lower limb prostheses since it guarantees the stability of the prosthesis while it is affixed to the residual limb, but also provides comfort. The shuttle lock system is one of the suspension systems and is much acclaimed for its operational simplicity and efficiency. This literature review focuses on aspects such as the design and function of shuttle lock suspension systems, and the advantages and disadvantages of the system in lower limb prostheses.

Overview of the Shuttle Lock Suspension System

Also called the pin-lock suspension system is a type of suspension that comprises a pin installed on the prosthetical liner that fits a lock present in the prosthetic socket. When the amputee wears the prosthesis in place the pin fits into a lock providing a proper connection between the residual limb and the prosthesis. It is particularly employed for transtibial, which literally means below the knee, amputees.

Gholizadeh, et al. (2014) conducted a study on the effectiveness of shuttle lock systems with an angle of view towards clinical uses. The participants said the system offered good stability and suspension but some of them suffered discomfort as a result of what they referred to as 'pistoning' which is the movement of the residual limb inside the socket. These problems were found by the study to be avoidable if the sockets were well-designed and well-fitted.

Ali et al., (2013) compared the SLS with other forms of suspensions including; suction and vacuum-assisted suspension systems. However, vacuum systems had a superior suspension on less pistoning compared with the shuttle lock system for its mechanical simplicity and lower cost. It was also favored by less mobile patients such as the elder patient since it is easy to wear and remove.

Biomechanical Considerations

Hafner and Smith (2009) reviewed the biomechanical of the shuttle lock system and how it affects the distribution of the load on the residual limb during walking. They discovered that as the system ensures safe attachment, it has some tendency of applying pressure on specific places in the limb making the skin uncomfortable and may even develop rashes. This research establishes the value of optimal socket design to enhance the pressure distribution.

Board et al. (2001) also on the same population aimed at comparing the various pin-lock systems on the overall biomechanics of gait. The study showed that, while offering stable suspension shuttle lock systems limit the articulation of the limb during walking. This limitation could also promote compensatory gait patterns which if overlooked could in the long run precipitate musculoskeletal disorders.

Patient Satisfaction and Usability

Gailey et al. (2008) conducted a study relating to the satisfaction level of lower limb amputees with various suspension systems, including the shuttle lock system. Analysis of the results displayed that while still acknowledging the effectiveness of the use of the shuttle lock system, participants' common complaints included discomfort and skin rash. Also, the system is said to be complex to manage, especially for people with restricted hand movement as the pin has to be placed perfectly in the lock.

Klute et al. (2011) the outcomes of a study in which participants with different degrees of limb loss and/or decreased mobility assessed the feasibility of using shuttle lock systems. According to their research, it was revealed that the system applies to moderately active clients, though the more complicated suspension systems such as the vacuum-assisted systems are favored by the highly active clients owing to enhanced suspension and comfort.

Shuttle Lock Mechanism

- Locking Mechanism: A lock is positioned at the bottom of the prosthetic socket which is known as the shuttle lock. In placing the pin at the liner, it forms a lock with the shuttle which gives the prosthesis a fixed position to the residual limb. The lock often has a push button which helps the wearer to detach the prosthesis.
- Prosthetic Socket: The prosthetic socket is the solid part that encompasses the residual limb referred to them. This one is tailored to the shape of the residual limb of the wearer and the shuttle lock mechanism is included too.

Limitations of the Shuttle Lock Suspension System

Nevertheless, the shuttle lock system has some demerits even though it has the following merits; Itching and skin rash is one critical point where pistoning is likely to occur and it thus requires attention. Also, the high tolerance between the limb and the prosthesis restricts the fluid movement of the limb and over time results in improper gait patterns. The system also needs to be maintained often so that it can be locked properly, this may prove tiresome to some people.

- Mechanical Failures: Common issues include pin breakage, lock jamming, or socket wear.
- Maintenance Requirements: The lock mechanism needs regular lubrication and

the pin and socket must be inspected frequently.

Comfort of Shuttle Lock Suspension Systems

- **Fit and Alignment:** Proper socket fit is crucial for comfort. Misalignment or poor fit can cause skin irritation or discomfort.
- **Pressure Distribution:** Research has shown that the shuttle lock system can create pressure points on the residual limb, leading to discomfort.

Benefits of the Shuttle Lock System

The Shuttlelock suspension system has several key benefits for people with transtibial prosthetics:

- **Secure Fit:** It makes sure that the prosthesis is optimally and securely worn on the residual limb so as not to cause slippage while exercising which in turn, gives its users a sense of stability and security.
- **Easy to Use:** This mode of dressing is easy to put on and remove thus convenient, especially for those with restricted hand movement such as the elderly and those with arthritis.
- **Affordable:** The Shuttlelock system is less expensive compared to more advanced systems like vacuum-assisted suspension, making it a cost-effective option.
- **Adjustable:** Users can adjust the fit by adding or removing socks between the liner and the limb, accommodating changes in limb size.
- **Comfortable:** Locking the prosthesis in place, reduces movement within the socket, which helps prevent skin irritation and increases comfort.
- **Durable:** With fewer parts that can break down, the Shuttlecock system tends to last longer and requires less maintenance.

- **Improved Mobility:** A secure fit may positively affect the user's perceptions of the limb, which can in turn affect the manner in which he or she walks or moves around.

Clinical Considerations

Skin Health: The condition of the skin on the residual limb is important. Skin condition of the residual limb is essential. If the socket is not compliant with the patient's anatomy or if there are issues with the skin already then, the Shuttlelock system may lead to some degree of skin breakdown or breakdown at the site of some of those devices.

Limb Volume Changes: Some people have a situation where the size of the residual limb is continually changing. There is a need to revisit the Shuttlecock system after some time to check whether they are still comfortable where they are placed as well as to check whether the system still fits them well.

Activity Level

- **Active Users:** The Shuttlelock system ensures fit and this is valuable for dynamic individuals; however, it may not be as adjustable as the other systems that are being developed.
- **Sedentary Users:** Less active users will find it convenient to use in addition to being stable most of the time.

Prosthetic Fit and Alignment

- **Proper Fit:** For the Shuttlelock system to work it has to be on a socket that should fit well. Misfit brings discomfort in the wearing of the prosthesis, the motion, and in general function.
- **Socket Design:** The form of the socket needs to be tailored to the particularities of the locking device and also to provide equal force distribution to prevent rubbing and causing discomfort to the user.

Maintenance

- Regular Checks: Other features; the locking mechanism should always be checked for signs of wear as this will lead to desired outputs. It should be washed and greased appropriately in order that it may operate efficiently.
- Adjustments: Occasionally changes may have to be made to continue to maintain the fit and function of the system.

Patient Education

- Usage Instructions: The users should be taught how to don and doff the prosthesis, get the correct size, and maintain the Shuttlelock system.
- Recognizing Issues: Patients should know how to spot common problems like skin irritation or poor fit and when to get help.

Comfort and User Feedback

- Comfort Levels: Collecting feedback from users about comfort and satisfaction is important to make sure the Shuttlecock system meets their needs.
- Adjustments Based on Feedback: If users report discomfort or other issues, adjustments might be needed to improve comfort and performance.

Materials and Methods:

Study Design and Setting

This was a purely experimental study carried out with the aim of ascertaining the credibility of the Shuttle Lock suspension system in lower limb prosthetics. The study was carried out at Ghurki Trust Teaching Hospital in Lahore over a group of transtibial (below knee) amputees using a Pakistani-made Shuttle Lock system prosthetic limbs.

Materials

The Shuttle Lock suspension system was

fabricated locally using aluminum because of its lightweight nature. For the purpose of assessment some measuring tools such as goniometers to measure angles, pressure sensors as well as motion analysis systems were used.

Sample Size and Selection Technique

Four participants took part in the study and purposive sampling was used in the study, this means that participants were chosen because they were able to meet set criteria.

Selection Criteria:

Inclusion Criteria

1. Till now we have patients who have had major amputation involving transtibial prostheses with minor complications.
2. In the survey, the sexes were also accommodated, both male and female.

Exclusion Criteria

1. Diabetic patients.
2. Patients with skin complications.

Patient Data and Questionnaire Analysis

Study Overview: This investigation sought to determine the quality, comfort, usability, resilience, and security associated with the Shuttle Lock suspension system for the TG-3 prosthesis that is locally developed. For the purpose of data collection, there was used a structured questionnaire which was completed by four patients to reflect their experience and satisfaction.

Patient Demographics: Four male transtibial amputees participated in the study ranging from 20 to 60 years of age. Below is a summary of their feedback: Below is a summary of their feedback:

Patient 1

- Comfort: 78% found comfortable for

everyday wear for a wristwatch.

- Security: Nine out of ten pointed out that it did not come off during activities.
- Ease of Use: The responses revealed that 75 percent of the users found the device easy to use.
- Durability: 8 of 10 patients had no problem in the specified system for about a one-year period.

Patient 2

- Comfort: The comfort for daily use was stated as high by 76% of the respondents.
- Security: 91% of respondents said that the prosthesis remained intact during the activity and did not become loose at any one point in time.
- Ease of Use: CE: 74% of the users reported that -iao was easy to use.
- Durability: Thus, 12 of them had no problem with the system for 12 months with 80 percent as the response rate.

Patient 3

- Comfort: Among them, 75% of respondents said that it was comfortable to use in daily life.
- Security: As many as ninety percent responded that the prosthesis felt secure during various staking.
- Ease of Use: Seven percent reported that it was very easy to utilize the site while seventy-one percent said that it can be fairly easy to use.

- Durability: A further 82% made no complaint about the system during the 12 months.

Patient 4

- Comfort: 72% of users stated that it was comfortable for everyday use.
- Security: Regarding security and stability of the prosthesis the following responses were obtained: 92% of the subjects indicated that the prosthesis remained in place during the activity.
- Ease of Use: 74 % said that they found it easy to use.
- Durability: It was found that 80% of the users had no problems with the system 12 months after its implementation.

Summary of Findings

The questionnaire results showed that the Shuttle Lock suspension system was generally well-received by the transtibial amputees. Key findings include:

- Comfort: 72% to 78% of patients found the system comfortable for daily use.
- Security: 90% to 92% of users felt that the prosthesis stayed securely attached during various activities.
- Ease of Use: 70% to 75% of participants found the system easy to use.

Durability: 80% to 82% of users experienced no issues with the system over 12 months.

References

- Ali, S., Asif, R., & Khurshid, M. (2013). Comparative analysis of different suspension systems for transtibial prostheses. *Prosthetics and Orthotics International*.
[Google Scholar](#) [Worldcat](#) [Fulltext](#)
- Board, W. J., Street, G. M., & Caspers, C. (2001). A comparison of trans-tibial amputee suction and vacuum socket conditions. *Prosthetics and Orthotics International*, 25(3), 202–209.
<https://doi.org/10.1080/03093640108726603>
[Google Scholar](#) [Worldcat](#) [Fulltext](#)
- Gailey, R., Allen, K., Castles, J., Kucharik, J., & Roeder, M. (2008). Review of secondary physical conditions associated with lower-limb amputation and long-term prosthesis use. *The Journal of Rehabilitation Research and Development*, 45(1), 15–30.
<https://doi.org/10.1682/jrrd.2006.11.0147>
[Google Scholar](#) [Worldcat](#) [Fulltext](#)
- Gholizadeh, H., Osman, N. A., Eshraghi, A., Ali, S., & Razak, N. (2014). Transtibial prosthesis suspension systems: Systematic review of literature. *Clinical Biomechanics*, 29(1), 87–97.
<https://doi.org/10.1016/j.clinbiomech.2013.10.013>
[Google Scholar](#) [Worldcat](#) [Fulltext](#)
- Hafner, B. J., & Smith, D. G. (2009). Differences in function and safety between Medicare Functional Classification Level-2 and -3 transfemoral amputees and influence of prosthetic knee joint control. *Journal of rehabilitation research and development*, 46(3), 417–433.
[Google Scholar](#) [Worldcat](#) [Fulltext](#)
- Klute, G. K., Berge, J. S., Biggs, W., Pongnumkul, S., Popovic, Z., & Curless, B. (2011). Vacuum-Assisted socket suspension compared with PIN suspension for lower extremity amputees: effect on fit, activity, and limb volume. *Archives of Physical Medicine and Rehabilitation*, 92(10), 1570–1575.
<https://doi.org/10.1016/j.apmr.2011.05.019>
[Google Scholar](#) [Worldcat](#) [Fulltext](#)