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Title
The Milwaukee - Socket: Scientific Findings as the Foundation of an Improved General Trans-Femoral Socket Design Concept

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Summary
Experimental assessment of isometric hip moment in amputees, as well as biplanar fluoroscopy studies provided the basis for several conceptual modifications of current trans-femoral socket designs. The developing of the theoretical framework was followed by a first practical trial of the new socket.

Introduction
Recent designs for trans-femoral sockets, starting with Long's NSNA [1], Sabolich's CAT/CAM socket [2], and not ending with Ortiz' MAS system [3, 4], although based on biomechanic reasoning and proven in everyday's practice, have generally evolved over considerable time spans and mainly as a product of the inventor's personal experience.
To thoroughly understand the situation in the trans-femoral stump and the functioning of current socket designs, was topic of a range of studies, including gait analyses, electro-myography, and isometric force measurements[6], the latter being a well defined criterion to estimate the effectiveness of a stump bedding design. The information which muscles experience the greatest restrictions gives a hint what section of the socket may be improved.
DRSA (Dynamic Roentgen Stereogrammetric Analysis) has recently been adopted for in-vivo assessment of prosthesis [5]. Findings suggest that the general concept of trans-femoral sockets can be improved.

Methods
The results of isometric force measurement in above knee amputees and previously published findings from DRSA studies on the stump/socket interaction during gait were combined to establish the theoretical foundation of an optimized fitting concept. Consideration of changes in

isometric stump forces inside the socket and observations from the relative motion of the stump with respect to the socket during walking, led to three major deviations from traditional designs (CAT/CAM or MAS):

- Abdication of the super trochanteric lateral socket wall component
- Abolition of rigid ramus containment and “bony lock” in favor of a “muscular lock”
- Addition of an L-shaped lateral posterior support structure to stabilize the femur

A prototype was manufactured and fitted to a 21 year old volunteer for first practical tests. Function and comfort was assessed by the subjective feedback of the amputee, and the judgment of a certified prosthetist.

Results

The upper lateral part of the socket wall has been shown to have no beneficiary effect for prosthesis stability or muscle force exertion. It can even impair the walking pattern and subjective perception of the prosthesis, why it was removed. Welcome side effects of this modification include better range of motion and less restricted muscle play, as well as cosmetic advantages.

For the ramus pubicus, riddance from the medially applied pressure results in a substantially reduced inconvenience level. The (distally) surrounding muscle tissue is capable of providing the required load bearing, as long as it is properly embedded. By including the hip extensors, which are tensed at heel strike, in the equation, the bony support can be entirely abandoned. The wedge blocking then takes place between hip extensors and the subtrochanteric parts of the femur bone in one direction and between the hamstrings and the rectus femoris muscle in the other direction. The glutes can be spared from rigid containment in the interest of free extension movability. Also no structural stability for the ramus “dent” is required anymore.

DRSA tests of MAS prosthesis walking revealed that upon heal contact the femur tip moves towards distal and lateral – resulting in Duchene-limp. An L-shaped guidance structure lateral posterior is to better this unwanted excursion. The change in insertion angle of the remaining abductor and extensor muscles is expected to reduce callus exostoses and related problems.

Conclusion

After years long experience with modern socket designs, extensive studies of isometric stump forces, and the chance to participate in the first DRSA tests of trans-femoral prosthesis walking, our proposed new socket concept includes the quintessence of various lessons learned. While first practical trials have been promising, it remains subject to further work, to investigate the clinical viability of our findings. Provided that clinical trials will be successful, it is suggested to name the design “Milwaukee-Socket” in recognition of the city of its first realization.

References

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