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Title
Trans-femoral Flexible sockets: balancing flexibility, rigidity, optimized fabrication, and cost

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Summary
A novel production of an affordable flexible trans-femoral socket with balanced flexibility/rigidity using High Temperature Volcanizing (HTV) silicone is undertaken. The use of readily available raw materials for such production is emphasized to assure its re-production in limited resources setting

Introduction/ basics
Several designs for flexible trans-femoral sockets are available with varying degrees of flexibility, equipment and technical skills required to fabricate, and cost/affordability1,2,3,4. Several problems with socket interface in lower limb prosthetics has been reported. Most previous flexible silicone sockets for trans-femoral amputations require either specialized equipment or high technical skills to fabricate; many of these sockets witnessed the separation of the middle rigid layer from the softer silicone layers due to the sharp rigidity contrast between the two materials. The design and production introduced here balance between flexibility, rigidity, ease of production, simple equipment requirement, availability of materials, and affordable cost of fabrication. It offers a solution to the separation problem.

Material method; implementation/ process
This new flexible TF socket design uses simple raw materials readily available for most P&O settings. It consists of three layers made in three stages; two layers of silicone and one laminated layer sandwiched in between. The main materials used are: A two-part HTV silicone for the inner and outer silicone layers, linen fiber and carbon fiber for the sandwiched middle layer which provides the gradual rigidity and anchoring of the socket adapter. The first layer of HTV silicone is laid on the dry smooth plaster model then cured in the oven at 100 # for 60 minutes. Then it is prepared for the middle sandwiched layer of laminated linen fiber using

Acrylic 80-20 resin. A small layer of carbon fiber is added distally. The linen fiber provides flexible rigidity in contrast with carbon fiber which is very stiff. Trim lines are established and large holes are drilled in it for connecting the inner and outer silicone layers. The outer silicone layer is laid and cured like the first layer.

Results

The final socket composed of bonded three layers offers maximum flexibility in certain areas (mostly the proximal brim), mixed flexibility and firmness in the middle section of the socket and good rigidity at the anchor distally. The flawless gradual transition between these three areas is achieved via the linen fiber which offers firmness but with high flexibility at the same time. Hence, there is gradual rigidity in the socket. Unlike other designs that utilize pure carbon fiber in the middle section, this design assures no separation between the three layers because the step stress found in previous designs is eliminated. The flexible edges of the linen fiber lamination allow flexibility in certain areas of the socket to match the flexibility of the silicone layers resulting in a uniform gradual transition from flexible areas to firmer areas rather than the sharp transition from high flexibility to high rigidity found in other designs. This new design offers an affordable solution because the basic raw materials are not expensive and they can be sourced easily. In addition, the fabrication does not require any specialized high cost equipment; just the regular P&O equipment found in most P&O workshops suffice; hence, this technique is re-producible in most P&O settings. This simple technique also allows the imbedding of electro-myo-graphic sensors inside the socket during fabrication because no high pressure or temperature are needed during its fabrication.

Discussion/ conclusion; conclusion for the practice

The following points are achieved with this new flexible TF socket design:

1. Gradual optimized flexibility and rigidity, thus, eliminating step stress and sharp contrast between the layers and the elimination of separation between the socket layers
2. Affordable fabrication in basic P&O workshops without the need of central fabrication or expensive equipment
3. Readily available (easily sourced) raw materials make it possible to produce such socket in most P&O settings

4. Longer life socket and possibility of adjusting flexibility in needed areas; also, possibility of imbedding sensors inside the socket

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Image: 16b 2nd pc silicone inner_128.jpg

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Image: 2a Materials used_131.jpg

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