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ELEMENTS FOR THE CONSTRUCTION OF THE PROSTHETIC USED ON THE LOWER LIMB

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Abstract: *A wide range of prosthetic systems is used in the transtibial amputation. There is a wide use of the prosthetic system for transtibious amputees. The use of such prostheses is based on a J-shaped prosthesis. The construction of such a lamella raises a series of problems presented in the paper.*
Keywords: *Transtibial amputation, prosthetic lamella, prosthetic systems, prosthesis*

1. INTRODUCTION

Polymer materials are composites made of a polymeric matrix formed of a polymeric resin (thermorigid or thermoplastic), reinforced with: continuous, or fragmented metallic, organic, ceramic, etc.; additives; filling materials. The way of placing the reinforcement material in the polymeric matrix determines the specific properties of the composite [20]: homogeneous properties (isotropic properties), non-homogeneous properties (anisotropy properties) mechanical, thermal loading characteristics, etc. Due to these properties, the polymer composites exhibit a great diversity of constructive uses: constructions; medicine; sports, consumer goods.
Polymeric medical composites used in medicine [7], [2], [3], [14] have the polymeric matrix and the reinforcing material made up of biomaterials: natural materials; thermoplastic or thermoplastic synthetic polymeric biomaterials, absorbable or non-absorbable polymeric biomaterials; vital or non-living biomaterials, etc.
These medical composites are used in a wide range of medical applications and devices. In orthopedics, the applications are very diverse, presented in Table 1. In the field of sports, polymeric medical composites are used predominantly in prosthetic systems for transtibial amputation (athletes with transtibial amputation) [9], [11], [12], [10].

Table 1 Application of polymeric composite material in orthopedic, after [3], [13]

Application	Composite material
Intramedullary nails	CF/LCP,CF/PEEK, GF/PEEK
Tendone / ligaments	PET/PHEMA.KF/PMA,KF/PE,CF/PTFE,CF/PLLA,GF/PU
Bone plates and screws	CF/PEEK,CF/EPOXY,CF/PMMA,CF/PP,CF/PS,CF/PLLA,CF,PLA, KF/PC, HA/PE,PLLA/PLDLA
Total hip replacement	CF/EPOXY,CF/C,CF/PS,CF/PEEK,CF/PTFE,CF/UHMWPE,CF/PE
Bone cements	Bonepacles/ PMMA, titanium/PMMA,UHMWPE/PMMA,GF/PMMA, CF/PMMA,KF/ PMMA, bioglass /Bis-GMA
Knee replacement	CF/UHMWPE
Systems for amputation of upper and lower limbs	CF/UHMWPE HA/PE,PLLA/PLDLA

Transtibial amputation may be several ways [4], [5], [18]: amputation very short; short amputation; standard amputation, with a height of 12-19 cm; long amputation.

Depending on the size, the amplitude of the bust can be: 1. lung length (provides advantages in terms of supported stresses, static and dynamic, allows for easier attachment of the prosthesis); 2. average bust; 3. short boss in extension; 4. short flexion.
The size of the amputation stump plays an important role in the prosthesis process on: 1. the denture construction; 2. the shape of the prosthesis; 3. preparing the prosthesis to be attached to the amputee foot; 4. choosing the materials from which the prosthesis is made. Depending on the type of prosthesis, the following types of materials are used:

- Polymeric materials with an exoscheletic structure from the resin;
- Fiber reinforced polymeric composites, kevlar or carbon fiber;
- Polyethylene foam;
- Stainless steel, duralumin, titanium etc.;
- Mat fabric;
- Synthetic leather.

2. CONSTRUCTIVE CHARACTERSTICS OF THE PROSTHETIC USED ON THE LOWER LIMB

For transtibial prosthetic leg amputated can use several types of prostheses:
1. prostheses with a simple, conventional design of plastic or leather: Sach prosthesis, All Terrain Foot prosthesis, etc .;
2. modular prostheses;
3. power storage prostheses in the first part of the unipodal support and release of energy in the second part for propulsion;
4. Bionic prostheses.
At present, for athletes (running and sprint) athletes use energy storage prostheses [16], [19], [21]: sport prothesis feet, Springlite sprinter [21], Flex-Foot Cheetah (With Lamination connector and with connector), Flex-Sprint™ [19] Flex-RunTM. The world market is dominated by Flex-Sprint, Flex-Foot Cheetah and C-Sprint.
The flex-foot orthopedic prosthesis consists of the following components [16], [17] [15] (Fig.1):

- socket or the fitting sleeve;
- intermediate sleeve;
- prosthetic or dynamic foot in the form of a J-shaped blade [16], [18].

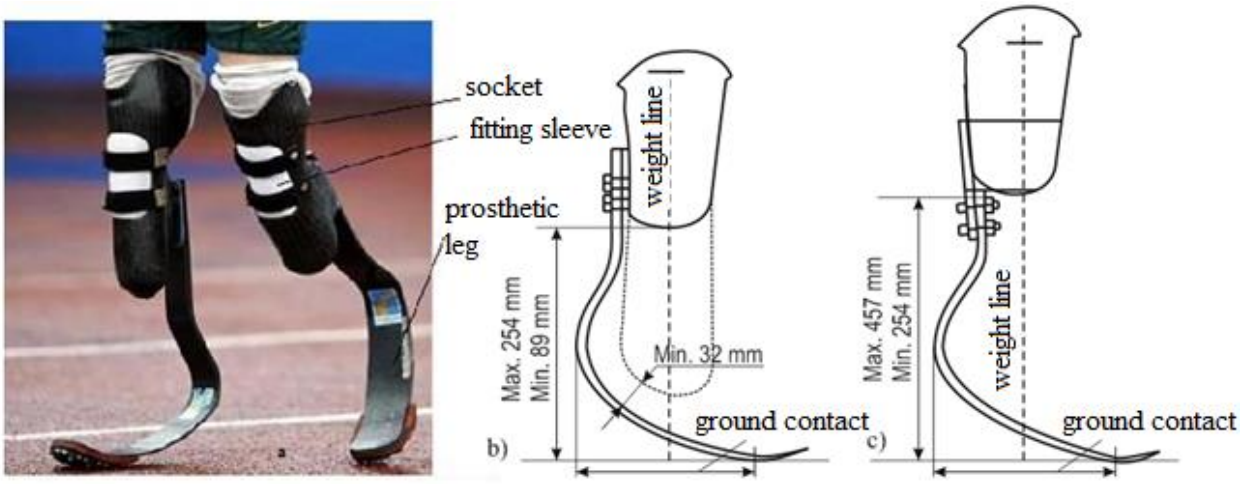

Figure 1 Prosthetic Flex-foot Cheetah: prosthetic trapped of the leg (a);. laminated connector prothesis (b); conector pilon prothesis (c), after [15].

The prosthesis replaces functionally the bone segment "tibia peroneu" and the leg.
The flex-foot orthopedic prosthesis has a number of constructive features that mention: not producing energy but instead storing and transmitting it; allows the athlete to participate in running competitions and went in conditions similar to those not trained in terms of kinematic and kinetic parameters of running and walking; are generally

lighter in comparison with biological feet; is personalized and at the same time ensures the safety of the athlete and the reliability in operation; allows easy attachment and removal to and from the transtibial amputee member, etc.
The prosthetic lamellas are generally made of carbon fiber composite materials, aramid and / or glass fiber combined with carbon fibers [19]. The carbon layered composite material consists of pre-impregnated epoxy resin layers, unidirectional and diagonal bonded carbon fiber.
The technology for making carbon prepregnat has the following characteristics [6], [1], [19] [20].
1. The pre-impregnation process consists in impregnating a carbon fiber fabric with epoxy resin after which the prepreg impregnated is brought into a partial polymerization state [19], [14];
2. The final formation is obtained in a furnace with adjustable pressure and temperature (autoclave) or vacuum bag;
3. the preimpregnat polymerization time is faster for prosthetic blades of small and slower shape or size for those of larger sizes and thicknesses [16].
The design of the prosthetic lamella made of pre-impregnated carbon fibers (Fig. 2) has as main input data: the functional characteristic of the material; the functional feature of the prosthetic lamella; the constructive feature of the prosthetic lamella; the security feature of the transplanted amputated athlete; the cost of manufacturing and selling the medical device.
The process of constructing the prosthetic lamellae comprises the following main steps:

Figure 2 Prosthetic plate pre-impregnated with carbon fiber, to the Flex-foot prosthesis

- Design of the prosthetic lamella in the required functional-constructive configuration;
- Designing the carbon fiber prepregs devices: the upper and the lower molds. Molds are executed on numerically controlled machines made of materials such as aluminum, duralumin, steel, etc.
- Designing and realizing templates for pre-impregnated cutting. Templates can be manufactured using materials that can be smooth and stretched on the surface of the mold and then cut or scored to the final size. It is easy to make and use plain cardboard, mat or paper fabrics;
- Cut pre-impregnated to the size and shape of the model. Before using the pre-impregnation, remove it from the freezing system and keep it for a while until it reaches room temperature. Next, plot the shape of the pattern using the template on the surface layer (protective film). Cutting pre-impregnated can be done very easily with a cuter or a pair of scissors.
- Applying pre-impregnated laminates to the upper mold. For this purpose, remove the laminate protective film, lay on the surface of the mold with the dry side facing upwards, and add a layer layer in the chosen configuration up to the thickness of the layered layer;
- Closing the molds and the model under vacuum bag and placing them in an oven (autoclave). It is a significant step regarding the vacuum packaging process and the polymerization temperature of the layered material.

The functional and constructive features of the projected prosthetic lamella are validated by simulating the behavior of the prosthetic lamella under real operating conditions [15].

3. CONCLUSION

Flex-foot Cheetah prostheses are mainly used for prosthetic lower limbs in transtibial amputees. The prostheses are composed of the following components: the socket or socket; intermediate sleeve; the prosthetic or dynamic foot in the form of a J-shaped blade; The "flex-foot" orthopedic prosthesis stores energy and transmits it to the prosthetic foot. The process of constructing prosthetic lamellae comprises a series of steps, presented in the paper.

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