Medical interest of 3D reconstructed limb to build a customized multicomponent bandage for the treatment of a lower limb lymphedema with partially amputated calf: a case report

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Introduction

Multicomponent bandage (MCB) is an essential method in the treatment of lower leg lymphedemas.[1,2] However, 2 layers bandages applying methods proposed by manufacturers do not result in selected pressures nor in a digressive pressure gradient and the proposed methods are not adapted for each type of case. For some particular lymphedema's patients, the therapist has to find a bandage applying method to obtain specific therapeutic criteria as the final stiffness of the assembled bandage, the expected pressure and a specific pressure gradient.

Objective

The aim of this study is to build a customized multicomponent bandage with selected pressures and a digressive pressure gradient for a patient with lymphedema and partially amputated calf (Figure 1). The patient underwent a lymphatic system infection of her right lower limb with partial inguinal node dissection, aggravated by a sepsis and a calf subcutaneous tissue infection. She cannot stand high-pressure levels on her limb, usually used during multicomponent bandage treatment for lymphoedema patient.

Materials and Methods

This experiment was conducted in 2 phases; first, on the 3D reconstructed lower limb and second on the patient herself.

- From the simulated limb, a very light foam prosthesis of the partial amputated right calf was customized in order to fill in the loss of the calf tissue under the future bandage. A 2 mm thickness custom silicone pad (medi® silicone for custom made liners, density A-5) was designed to be the protective skin interface layer of the prosthesis (Figure 2).[3,4]

Pressure sensors were applied at 10 different selected points (Figure 2). Multicomponent bandage consists on a first layer of tubular cotton jersey put directly on the skin, a second single layer of Mobiderm® (minimal overlap, no tension) and a last single layer of Biplast®. Biplast® overlap method was adapted with a constant band tension to obtain 20-25 mmHg at dorsal face of the foot (100% of pressure) and a digressive pressure gradient on the rest of the limb (2/3 overlap at the foot, calf and knee distal part; ½ overlap at the tight) (Figure 3). The foam prosthesis was placed on the silicone pad which was directly applied on the simulated limb under the multicomponent bandage.

- Bandage applying method was finally tested on the patient (Figure 3). Pressures were assessed in the same 10 locations on the patient's own right limb in standing position and during walking. Dynamic variation pressure indexes (DVPI) were calculated at each selected points (difference between maximal pressures and minimal pressures during walking), which represent *the local massage effect* or *pump effect* under bandage.

Results

On the 3D reconstructed member and on the patient, selected pressures at dorsal face of the foot was respectively 20 mmHg and 23 mmHg. Global internal and external digressive pressure gradients (Int PG, Ext PG) were also obtained with the selected applying method (Figure 4).

On the patient, DVPI (mmHg) demonstrated high massage/pump effects at the dorsal foot face (16), above the malleoli (8-6) and under the prosthesis (16), due to the final resistance of the assembled bandage. The customized multicomponent bandage was well tolerated by the patient during experiment.

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Discussion

Patient was previously treated by another therapist with multicomponent bandage including high pressures. It was a failure because she did not support high pressures (or common pressures used for a lymphoedema patient) especially at the thigh level due to the skin graft. For this reason, the higher tolerated pressure was evaluated on her foot during the first appointment. This low pressure was selected as the pressure reference at the dorsal foot face for her customized multicomponent bandage. Having a previous satisfactory experience concerning multicomponent bandages applied with very low pressures and global digressive pressure gradient for lymphoedema patients (Leduc's method), those two pressure paramaters were the solution to build a tolerated bandage for the patient.

Those pressures were possible to obtain due to the selected applying method, the global conic shape and the circular section all along the limb.

In this case, recorded DVPI during walking were not only due to the final stiffness of the assembled bandage, but also to the limb volume change. The patient walking difficulties (inability to bend the knee) and the amputated calf explain the poor"

Figure 1. View of the patient lower limbs (left), her partially amputated calf and her thigh and her inguinal node dissection scar.

DVPI at the tight level.

Silicone pad was selected as a safety protective interface between skin graft and the prosthesis to reduce local mechanical stress on the calf skin scars (medical propriety used during scar management)[4] but also for two other technical reasons (washable and reusable).

The association between Mobiderm® (stiff layer) and Biplast® (adhesive layer) leads to an *adhesive* short stretch (inelastic) final assembled multicomponent bandage. Mainly, Mobiderm® band is used in association with a non-adhesive short stretch band in lymphoedema treatment.[5] Our kind of adhesive MCB completes the tools range (non-cohesive or cohesive MCB) at the disposal of the therapist.

For this patient, staying in the same standing position or walking during a long time was very difficult. Working on 3d reconstructed limb was the solution to build a customized multicomponent bandage and offered the possibilities to practice multiple tests (products choice, best applying method). It was like having *the patient* in our lab.

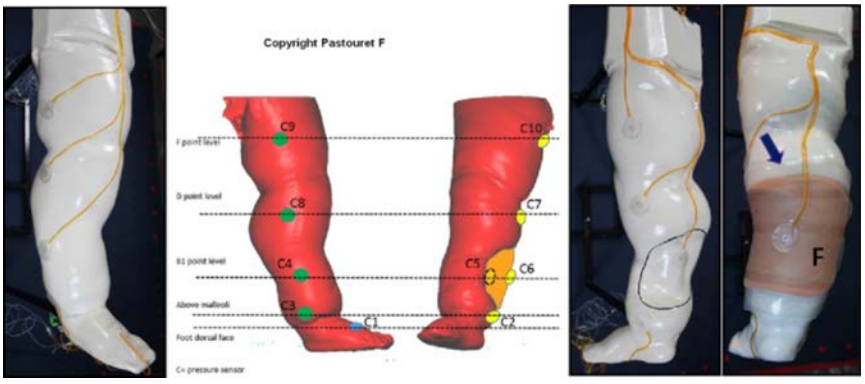

Figure 2. Pressure sensors locations on the 3D reconstructed limb. C5 is located under the silicone and the prosthesis. C6 on the prosthesis; Silicone pad: Medi® silicone for custom made liners, density A-5 (blue arrow); Light foam prosthesis of the partial amputated right calf (F).

Figure 3. Multicomponent bandage applying method on the 3D reconstructed limb (left) and on the patient (right). First layer of tubular cotton jersey (A). Second single layer of Mobiderm®, minimal overlap, no tension (B). last single layer of Biplast ®. Biplast®, digressive overlap and constant band tension (C).

	3D reconstructed member				Real member of the patient						
	3 tries (mean and sd)				Rest				DVPI mmHg (walking)		
Sensors	Pressures	%	Int PG	Ext PG	Pressures	%	Int PG	Ext PG	Max P	Min P	DVPI
C1 foot	20,3 ±1,5	100%	100%	100%	23	100%	100%	100%	21	5	16
C2 Int Mall	19±2	95%	95%		14	61%	61%		15	7	8
C3 Ext Mall	6±3,5	30%		30%	10	43%		43%	13	7	6
C4 B1 ext	8±1,7	39%		39%	13	56%		56%	14	10	4
C5 B1 under prothesis	1,3±1,1	6%			18	78%			32	16	16
C6 B1 on prothesis	8,7±1,1	43%			8	35%			8	8	0
C7 D int	10,7±0,6	52%	52%		10	43%	43%		12	10	2
C8 D ext	6±1	30%		30%	14	61%		56%	12	12	0
C9 F ext	5,7±1,1	28%		28%	8	35%		35%	6	6	0
C10 F int	7,6±0,6	37%	37%		10	43%	43%		10	8	2
	mmHg				mmHg				mmHg	mmHg	mmHg

Figure 4. Recorded pressures (mmHg or %), internal and external pressure gradients (%) and DVPI during walking, according the sensors location.

Conclusions

The use of simulated limb in compression therapy *in vitro* experiment to assess related pressure parameters is common.[6-9] Working on 3D reconstructed limb to prepare a customized multicomponent bandage for a specific patient is a new concept in compression therapy that allowed decreasing the patient time's investment.

Custom prosthesis with the silicone interface enabled to normalize the leg's shape, to protect the skin scars and to obtain a high massage/pump effect on the skin graft, which is a very important skin care benefit during the treatment. Final pressure, pressure gradients, DVPI and final resistance of assembled bandage are very satisfying and are leading to an optimal bandage tolerance by the patient.

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