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NEW TRENDS IN MEDICAL APPLICATIONS BY USING TECHNICAL TEXTILES

Traditional medical casts like Plaster and plastics are; heavy, not washable, do not offer a suitable fixation for bones fractures and always in individually sizes. They are also cannot offer the required stabilization for bone fracture. By using technical textiles, a new pneumatic cast has been developed in this study. This developed cast depends on some special materials like coated fabric, skin friendly spacer fabrics, air chamber and metal braces. The new developed cast can control the pressure on the injured part by using a pneumatic system. In a comparison with traditional casts (plaster and plastics), this pneumatic cast is; easy to use, comfortable, light weight, washable, mass-produced and provide the required pressure on bones fractures during swelling conditions.

Keywords: *Technical Textiles, Medical Textiles, Bone Fracture, casts, Comfort*

State of research. The world textile industry is moving rapidly toward the manufacture of high-added value textile structures and products (1). Medical textiles are one of the most rapidly expanding sectors in the technical textile market, and hosiery products with medical industry applications are among a long list of textile products being consumed in the textiles market. The medical applications of technical textiles are widely used nowadays in several fields such as health care, extra corporal devices, surgical applications and orthopedic products (2)(6)(8)

The main goal of bones fractures treatment is to restore the normal form and the continuity of the bone and return to the complete usability to the injured part. The purpose requires two kinds of treatments according to the fracture type; the first is a conservative treatment and the second is operative treatment. This study makes more focus on the hand radius fracture (hand wrist) which is the most often fracture and acts between 10 and 25% of all fractures. Women are concerned up to three times more often than men (3). In a typical radius fracture, a quick swelling appears and the whole wrist region is painful. Most of fractures become immobilized in stable gypsum form (Plaster) for 4 – 6 weeks (4)(7)(11)

Motivation & objectives. Plaster and Plastics casts are that it is heavy, not washable and difficult to use. Also the plastic cast has some disadvantages like high cost and skin irritation (9)(10). The main disadvantage of both of them is that they do not offer a suitable fixation for bone fractures during the different swelling conditions. After swelling decrease, the cast will be in a hard form and the stabilization effect of the cast is insufficient because of the distance which occurs between the skin and the cast (Fig.1).

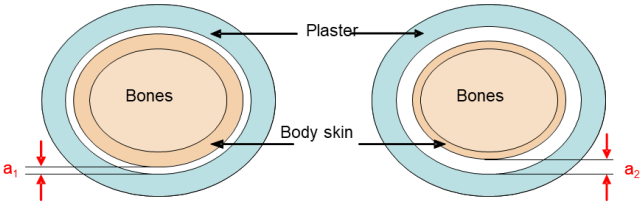

Fig.1:**Distance change (a) between the skin and the cast during (left) and after the swelling (right)**

Therefore, the objectives of this study are:

- Developing a new pneumatic cast that can overcome the difficulties of the cast fixation with the injured part of the body.
- Realization of permanent stabilization by using a pneumatic support structure during and after the swelling.
- Improvement of the physiological behavior of the available pneumatic casts by using innovative and comfortable textiles.
- Producing an economic product, that should be easy to use, light weight, comfortable, skin friendly, water resistant, easy to clean, and with a good price.

Methodology. By using the 3D design, the pattern of the cast is anatomically built in two categories of sizes (A) and (B) and every category includes two sizes; the first category (A) includes sizes S and M, and the second category (B) includes sizes L and XL (Table 1). Only one cast is available for more sizes in the same times. The basic measurement of all sizes is the wrist circumference (w), beside other sub measurements such as underarm circumference (u), corpus circumference (c) and the length of the cast (l)(Fig. 2).

The cast consists of two basic parts: front and back (Fig. 3). The front part contains an outer layer made of PVC coated fabric with indirect contact to the skin, air chamber that made of rubber coated fabric and contains a valve, and an internal layers that include; cotton-viscose fabric which is in a direct contact

with the skin, and PES spacer fabric which makes more flexibility and comfortable to the skin. In addition, the cast has an external pumping system in order to pump air into the air chamber that causes the pressure on the radius fracture. The pneumatic structure includes a manometer with a pump and a rubber tube with a needle.

Fig.2. **Measurements of the cast**

Table 1 – **Categories of the cast sizes**

Category	Size (Wrist)	
A	S	15 - 17
	M	>17 - 19
B	L	>19 - 21
	XL	>21 - 23

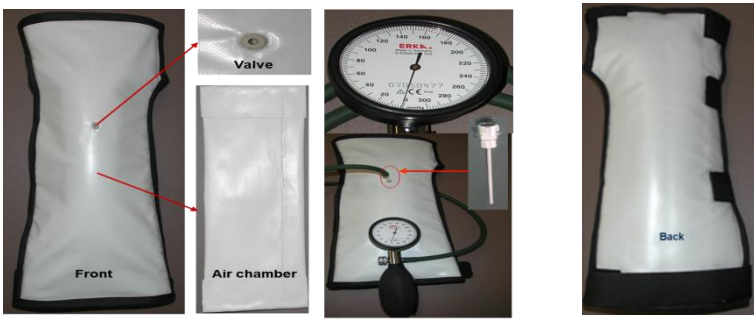

Fig.3. **Components of the developed pneumatic cast**

The back part of the cast contains also the same outer layer (PVC coated fabric) and the same internal layers (cotton-viscose fabric and PES spacer fabric) of the front part. In addition, the back part includes two metal braces that are anatomically formed as the hand in order to provide more stabilization to the cast under the hand. These two metal braces can be removed while washing or showering during a horizontal hole in the bottom of the cast. During pumping, the internal layer moves towards the radius fracture in order to realize a continuous pressure on the radius fracture after decrease of swelling and this is the main mission of this developed cast.

Research results. As shown in Table 2, several controlling tests, such as bending rigidity, weight and thickness, have been operated to several fabrics in order to choose the suitable fabric for the outer layer of the cast and the air chamber, that should be flexible, thinly, easy to clean, washable and light weight.

Heytex 55128 PVC coated fabric was used for the outer layer because of its lowest weight, thickness and bending rigidity. But the fabric of the air chamber should be lighter and more flexible than the outer layer because it expands during pumping; therefore, PTO.E rubber coated fabric has been used as a material for the air chamber.

Table 2 – **Tested fabrics for the outer layer and the air chamber of the cast**

Fabric	Coating	Weight [g/m²]	Bending. R [mN*cm]	Thickness [mm]	Thermo-plasticity
Valmex 7318	PVC	1000	120,68	0,9	Yes
Valmex 7316	PVC	630	113,23	0,7	Yes
Heytex 55128	PVC	600	63,54	0,5	Yes
Heytex 3561	PVC	700	80,75	0,6	Yes
PTO.E 13-606-48	NBR-Blend	580	20,96	0,5	No

The normal sewing technique is not suitable to build the air chamber because of the effect of the holes created by the needle during sewing; also the welding technique is not suitable for building the air chamber because of the non-thermo plasticity of the rubber coated fabric which has been selected for the air chamber. Therefore, the adhesive technique has been used to build the air chamber. Seam strength test has been operated for several adhesive materials. Figure 4 shows that Proma kleber adhesive material scored the highest value of seam strength and elongation; therefore, it has been used as a bonding material for the air chamber.

Most of recently scientific researches recommended that the maximum pressure that can be pressured on the skin is 30 mmHg. The British Standard (BS 7505) classified the pressure less than 20 mmHg is mild (5)(6), and the pressure up to 60 mmHg is very strong. Therefore, the pressure of the developed cast has been tested by Argus junior tester.

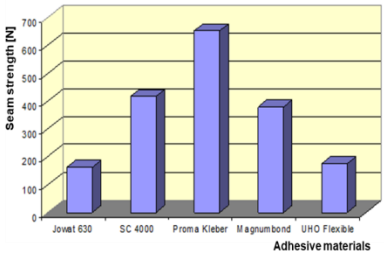

Fig.4. **Seam strength of the adhesive materials**

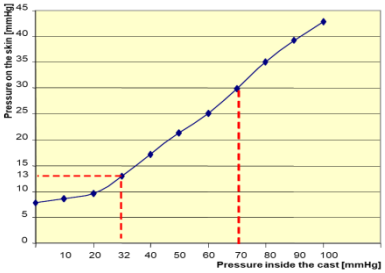

Fig.5. **Effect of cast pressure on the skin**

As step to study the effect of the cast pressure on the skin during and after the swelling, the values between 0 and 100 mmHg have been pumped inside the cast. At the same time, the effect of cast pressure on the skin has been scored by external pumping system (Argus junior tester) in case of without swelling (Fig.5). In order to make a simulation to the swelling, the wrist has been covered with some textiles layers that simulate the swelling thickness. The pressure on the skin during the swelling (without pumping) was 20,8 mmHg. But after the decrease of swelling, the pressure on the skin was reduced to 7,8 mmHg, suggesting that 13 mmHg as a pressure value on the skin (the difference between during and after swelling) is required to be pumped after the decrease of swelling in order to realize a constant enough pressure on the hand radius fracture during and after swelling. This value of pressure is equal to 32 mmHg of the cast pressure, and the maximum allowed value according to The British Standard classification (referred above) is equal to 70 mmHg of the cast pressure, more than this value is not comfortable for the blood circulation.

Washing test is one of the important tests that help to evaluate efficiency of the seam of the air chamber during a number of washing cycles in order to maximize the number of washing cycles. Because of the hygiene concept, the samples have been washed at 60 ℃ up to 15 washing cycles, and the washing test has been operated according to standard (DIN EN ISO 6330). The seam pressure resistance has been tested by the Textest FX 3000 water proof tester according to standard (DIN EN 1734). The sample before washing scored 663 mmHg which is the highest value of pressure resistance. The sample after 15 washing cycles scored 45 mmHg which is the lowest value of pressure resistance. As shown in Figure 5, the required pressure on the skin after decrease of swelling is only 32 mmHg of the cast pressure, suggesting that the cast can be washed up to 15 washing cycles.

Conclusion

In a comparison with Plaster and plastic casts that they are heavy, not washable, insufficient fixation after swelling decrease and always in individually sizes, the new developed pneumatic cast is light weight, washable, offer the required fixation to the injured part during swelling conditions and suitable for many sizes. The newly developed pneumatic cast depends on an anatomic form, pneumatic structure, metal braces and innovative textiles. As a comfort concept for the cast, it includes four internal layers (65% cotton–35% viscose and PES spacer fabric), and also many holes in the outer layer for more breathing. For more safety, recommended washing cycles are up to 10 times and up to 60 ºC.

Some parameters of the developed cast are still in progress such as the physiological behaviour. But the primary results say that this cast can be worn up to 4 weeks without any skin problems.

As a future vision for this kind of pneumatic cast, the smart textiles can be added to this cast by using an electronic system which includes special sensors and monitor that can be fixed with the outer layer of the cast in order to measure the pressure on the skin directly, but it will raise the final cost of the product.

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