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Pressure developed under pressure garment

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SUMMARY. **To study how much pressure develops under a pressure garment, and how to obtain adequate effective pressure for scar treatment, we have used garments in combination with sponge and plastic plates in human volunteers. The pressures increased significantly when a sponge or sponge and plastic plate were used beneath the garment compared to pressures using a garment alone. In evaluations in patients with scar tissue on the limb, similar findings resulted.**

Pressure treatment is a well accepted therapeutic procedure not only for hypertrophic scars and keloids, but also for the prevention of hypertrophic scars on healed burn wounds, contracture of grafted skin and oedema after mastectomy.[1] When pressure is applied to scar, it accelerates the natural remodelling process and results in flattening and softening of the scar.[2,3] It has been suggested that extreme pressure might cause circulatory disturbance or the breakdown of tissue.[1] There has been little information on how much pressure is adequate and how to apply adequate pressure.[1,4] We have previously reported that hydration and occlusion treatment is effective for treatment of hypertrophic scars and keloids.[5] We suspected that this treatment combined with pressure would be more effective. In pressure treatment, we believe that applying adequate and effective pressure is essential. We have evaluated the pressure developed on scars beneath a pressure garment under various conditions.

Materials and methods

A pressure monitor was made using a rubber balloon, connected to a catheter, and a Control-inflator (VBM Medizintechnik, Germany), which could measure pressure from 0 to 120 cmH_2O (88 mmHg). To evaluate the accuracy of the pressure monitor, the rubber balloon was placed in a closed rubber bag, which was connected to a manometer. The rubber bag was then compressed. The pressure indicated by our pressure monitor was equal to the value shown by the manometer in the range of 0 to 80 mmHg (Fig. 1).

Medium tension Tubigrip (Seaton, UK), chosen according to the manufacturer's measuring tape, was used. Reston sponges (3M, St Paul, USA) of 1.25 and 2.5 cm in thickness, cut to 4 × 5 cm were used to apply pressure topically. Two plastic plates, one pliable and thin (made of acrylic resin, and about 1 mm in thickness), and the other thick (about 3 mm) and hard, and made of Thermosplint® (Tokyo Eizai, Tokyo, Japan), were used. This was because we found that the developed pressure was increased by inserting a plastic plate between garment and sponge in a previous study. The manometer balloon could be placed under the Tubigrip at the appropriate site.

First survey

In 22 adult male volunteers, aged from 24 42 years (average 27.2 years), the pressure developed was evaluated at four test sites, namely the mid-lateral and mid-medial aspect of the forearm, the upper arm, the thigh and the leg, namely 10 cm above and below the elbow and knee joints where there was no bony prominence beneath the skin, according to Harries and Pegg.[1] An inflating balloon was placed on both lateral and medial test sites to evaluate the pressure simultaneously. Under the various conditions listed in the Table the pressures which developed were evaluated using pressure garments and/or sponge and plastic plates. Sponge or sponge with plastic plate was placed on the lateral aspect only. In each set of test conditions in any site, a new garment and sponge were used.

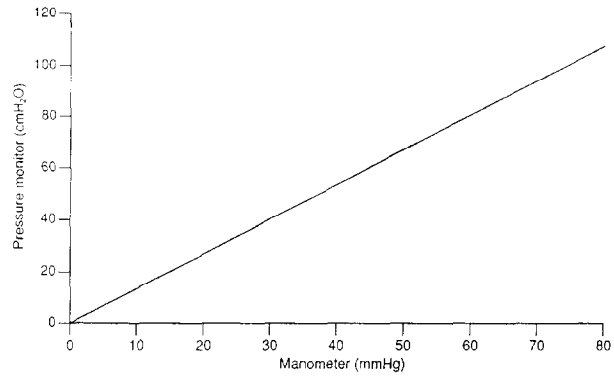


Fig. 1

Figure 1—Figure shows relationship between the pressure indicated by our pressure monitor and the value shown by the manometer, when rubber balloon was placed and compressed in a closed rubber bag.

Table Test sites and conditions in the first survey when only a garment was applied on the medial aspect

Test	*Test sites* *Mid-lateral aspect*	*Mid-medial aspect*	*Conditions (Lateral aspect only)*
1.	A	B	Garment only
2.	C	D	Garment with a thin sponge
3.	E	F	Garment with a thin sponge and a thin plastic plate
4.	G	H	Garment with a thin sponge and a thick plastic plate
5.	I	J	Garment with a thick sponge
6.	K	L	Garment with a thick sponge and a thin plate
7.	M	N	Garment with a thick sponge and a thick plastic plate

In every test, pressures on the medial and lateral aspects were evaluated simultaneously.

Second survey

In 17 patients, 12 males and 5 females, aged from 15–52 years (average 29.2 years), who had a small hypertrophic scar on an aspect of the upper extremity, the pressure was measured using a thin Reston sponge and thin plastic plate of the same size as in the first survey. In all cases, the area of the scar was larger than the applied sponge and plastic plate, *i.e.* the sponge did not cover the whole scar in this study. Pressure was measured at two sites, namely on the scar and on the opposite side of the same limb, where there was no scar tissue. At first, pressure was evaluated after application of a pressure garment alone on the limb, and then also after application of a thin Reston sponge only, and further with a Reston sponge together with a thin plastic plate on the scar.

Results

First survey

The average pressures which developed when medium tension Tubigrip was used in each test site are listed in Figures 2–4. When a garment was applied without sponge or a plastic plate, the pressure which developed on the lateral aspects in four test sites was from 11.5 ± 2.5 (upper arm) to 16.9 ± 4.9 mmHg (thigh). When a sponge was applied under the garment, developed pressure on the lateral aspect increased significantly in every test site ($p < 0.01$, Student's t-test). The increase in pressure was a little greater when a thick sponge was used compared to when a thin sponge was used; however, this difference was of little significance in any of the test sites. When thick or thin plastic plates were applied between the garment and

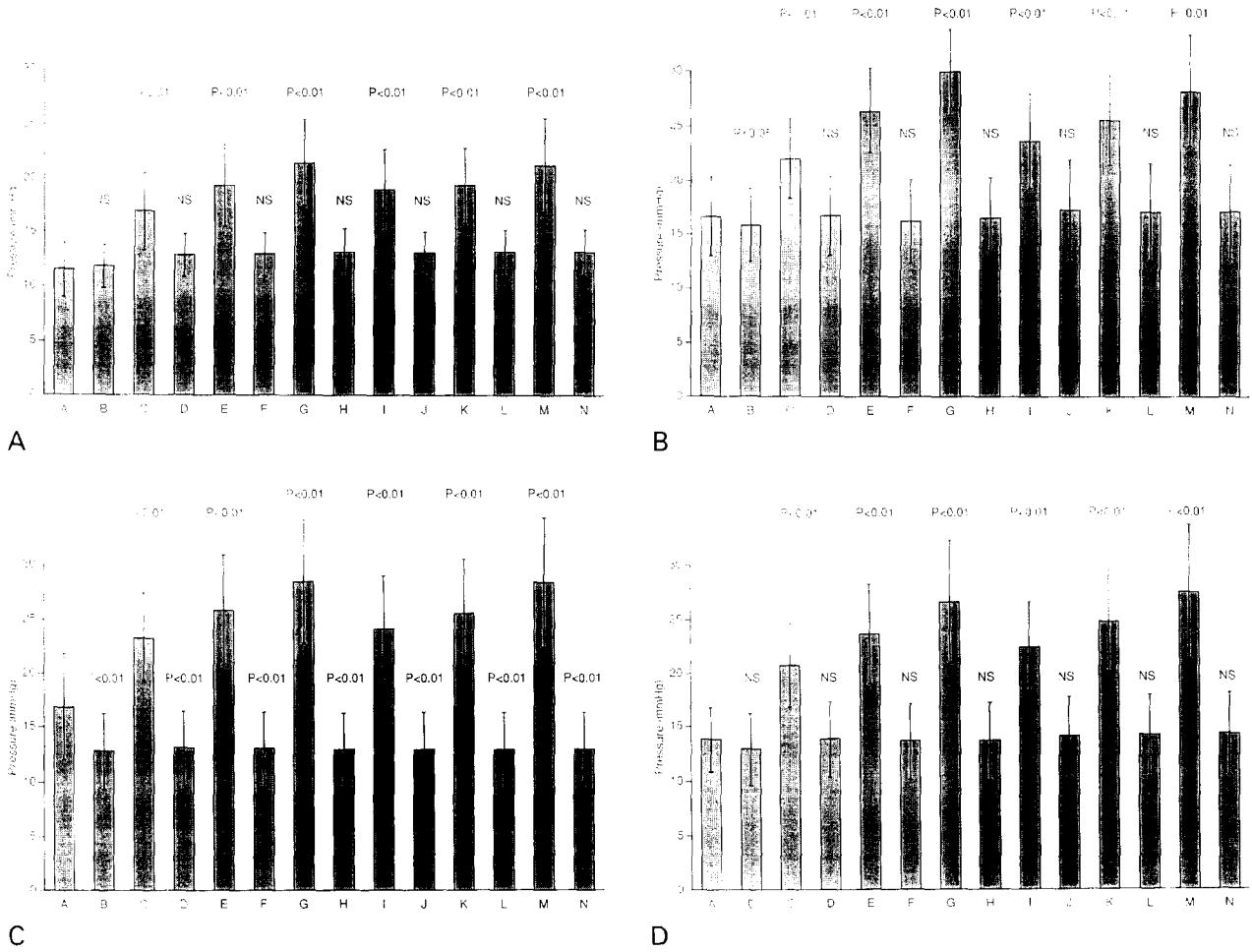


Fig. 2

Figure 2 The pressure under various conditions on (A) upper arm, (B) forearm, (C) thigh, and (D) leg.

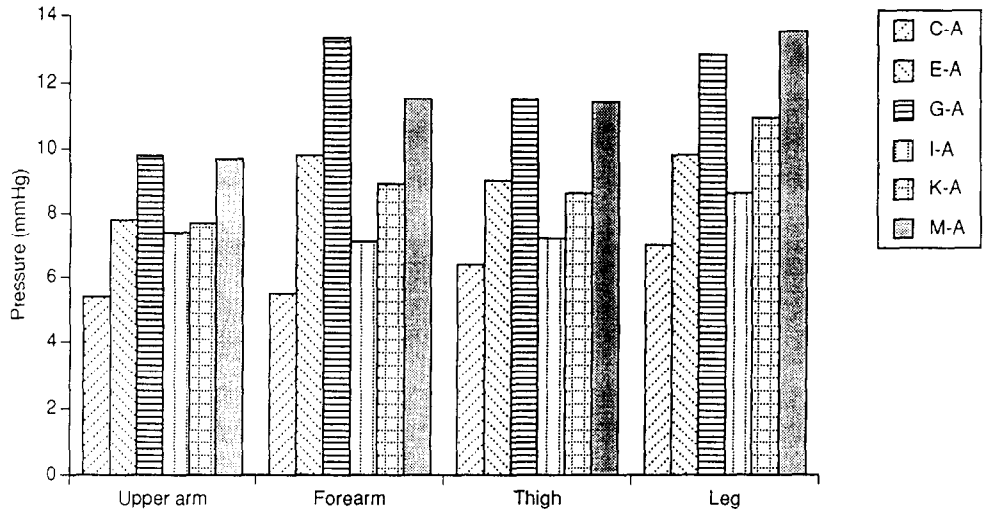
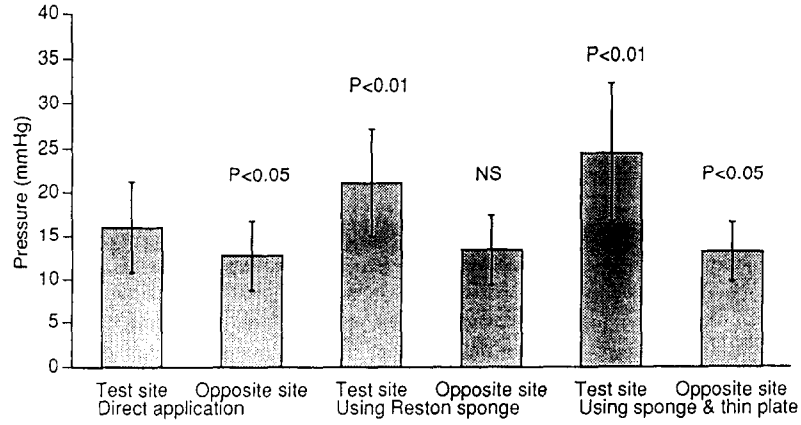


Fig. 3

Figure 3—Mean increases in pressure over four test sites from applying sponge and plastic plate under the garment as compared to garment alone.



Maximum pressure	29.9mmHg	21.6	32.8	20.1	44.8	20.1
Minimum pressure	11.2	6.0	12.7	6.0	14.2	7.5

Fig. 4

Figure 4—Results of second survey.

sponge, the developed pressure increased significantly compared to garment alone, or to garment with sponge in every test site ($p < 0.01$, Student's t-test). The increase in pressure was a little greater when using a thick plastic plate than in the case of a thin plate. However, statistically significant differences could not be seen between the use of a thick sponge and a thin sponge when combined with the use of plastic plate.

On the medial side of the limb in the four test sites, only a small increase in pressure resulted when a Reston sponge and a plastic plate were applied on the lateral side. When a garment alone was applied to the lateral side of the thigh, the pressure developed on the medial side was lower under all test conditions ($p < 0.01$, Student's t-test).

Among all the pressures recorded in the four sites under the various conditions, the majority of them were between 10 and 20 mmHg (56.4%), with pressures over 30 mmHg seen in only 5.5%.

Second survey

In clinical cases, when a garment was applied on the scar surface using a thin Reston sponge with or without a thin plastic plate, the pressure increased more than when a garment alone was used ($p < 0.01$, Student's t-test). The increase in pressure was significantly greater when a Reston sponge was applied with a plastic plate than without the plate ($p < 0.01$, Student's t-test, Fig. 4).

Discussion

Although many kinds of pressure monitors have been used in studies of this kind,[1-4] the accuracy of some of these has been questioned, and cost is too high for routine use.[1] Our first survey resulted in similar average values for various test sites to those reported

by Harries and Pegg.[1] They measured garment-scar interface pressure using the Oxford Pressure Monitor on soft tissue areas of the upper and lower limbs and hands and feet. However, in our study there was no case which showed zero pressure under a pressure garment. Using a pressure garment of medium tension, we feel that there is inevitably pressure present under the garment. Our pressure monitor was inexpensive (approximately £60) and can easily evaluate the pressures developed.

It has been reported that prolonged and excessive local pressure could result in circulatory disturbances or tissue break-down, even in normal tissues.[4] Compression of less than 30 mmHg around the entire limb is said to be safe.[7,8] Yamaguchi *et al.*[8] showed that external compression of 50 mmHg around the lower limb diminishes peripheral circulation, but compression of 30 mmHg has no significant effect. Campion *et al.*[7] reported that muscle blood flow was greatly reduced by compression of 40 mmHg. They also suggested that external compression of more than 30 mmHg should not be applied when an inflatable plastic splint is employed.

Although it is not clear how much pressure is effective when pressure treatment of a scar is being used, the majority of authors suggest that an interface pressure of greater than 25 mmHg is necessary.[1] As shown in our present study, and by others,[1,4,9] there are wide ranges of pressure for each body part, each body area, and each kind of garment.

It appears from this study that the combination of a pressure garment, a sponge and a plastic plate results in desirable pressures being attained.

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