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CLINICAL FASCIA RESEARCH

Changes in the structure of collagen distribution in the skin caused by a manual technique

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Manual treatment;
Ultrasound study;
Treatment effects

Summary *Objective:* When treating patients with functional disorders using a special manual technique, tissue changes can be felt by the therapist and the patient. This study was conducted to objectively document these changes.
Method: In the author's practice for body therapy, 30 patients were measured with high-frequency ultrasound (22 MHz) immediately before and after their first treatment in the area where they experienced pain or other discomfort and/or movement restriction.
Results: Highly significant differences can be seen in the structure of the collagen matrix in the dermis before and after treatment. These changes reflect the differences in tension, softness and regularity, which can be palpated before and after treatment and are thought to be caused by changes in the mechanical forces of fibroblasts and increased microcirculation.

Background

In the author's practice for body therapy, patients who mainly have chronic complaints that are referred to by the author as sensory motor disorders are treated. This means patients have unpleasant sensations such as chronic pain, nausea, dizziness, anxiety, depression, numbness, tingling, globus pharynges, burning feet, etc. At the same time they have movement disorders such as restriction, stiffness, instability, cramps, sudden weakness, voice disorders, speech disorders, restless legs, etc. The majority of these patients suffer from chronic pain and movement restriction and have several complaints. Their disturbances are often called functional, psychosomatic, neurogenic, or age-related disorders. It is usually assumed that there is no bodily source for these complaints or it exists only in the central nervous system, or that it involves degeneration of the bones.

From the clinical experience of the author, these disorders originate from the surface of the body. There is always a bodily basis of these disorders that can be found in the muscles, muscle fasciae (e.g. trigger points) or in the connective tissue of the skin. These changes can be palpated, and observed. Patients can pinpoint the site of their discomfort (for example anxiety at the front of their ribcage) although they may feel this discomfort as coming

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from within. A movement restriction (in breathing, for example) can be seen where patients show their complaints, and more often than not also a dimpling in the skin. Structural changes in the muscles, in muscle fasciae, or in the skin can commonly be palpated at these locations.

Besides the changes in the area of their complaints, patients may have patterns of heightened tension in other surface areas throughout their body, of which they may be completely unaware prior to treatment.

For treatment of all these bodily changes, Sensory Motor Bodytherapy was used, which consists of several hands-on techniques, movement, and body awareness training—combined with treating heightened tonus in muscles and connective tissue, thereby changing sensory impressions, movement, and posture.

One of the manual techniques employed is a treatment of the connective tissue of the skin using rolling and pressing movements of the fingers (Figure 1). This is not the common technique of skin rolling over large areas of skin. Rather, treatment is carried out in a very localised area, going back and forth in all directions with a pressing and squeezing of the connective tissue between the thumb and the index finger and then moving to the next small area only a few millimetres distant from the first one. After a short while, treatment is repeated at the first location. Via this method, the tissue is thoroughly worked through, 1 mm after the other (Figure 2).

At the beginning of the treatment, the afflicted area of the skin feels hard, firm, and cold to the therapist. The skin is not easy to move in this area and it has an irregular structure. Skin fold thickness is greater. For the patient it feels (very) painful when treating the afflicted area and the pressure used during treatment is perceived to be very strong. Patients regularly overestimate the power of the pressure. The same pressure used in a healthy area is estimated as being much less. In addition, treatment is not painful in non-afflicted areas—there seems to be oversensitivity to pressure in the affected area.

After a few minutes of treatment, the therapist feels the tissue becoming softer, warmer, and easier to move. A skin fold becomes thinner. This relaxation response is often very abrupt, from one moment to the next. At the moment of relaxation, patients report treatment to be less painful and sense the pressure as markedly reduced. Oversensitivity seems to have disappeared and this is when treatment at this site is considered complete.

Immediately after treatment, the patient feels the treated area as warm and more alive and as having lost the previous pain or discomfort. In the treated area, a reddening can be seen and sometimes a little swelling without other signs of lasting oedema. There is also a larger range of movement along with more stability in movement in this area.

Method

In a first step to objectively document the immediate changes caused by the treatment of the connective tissue of the skin, we conducted an ultrasound study.

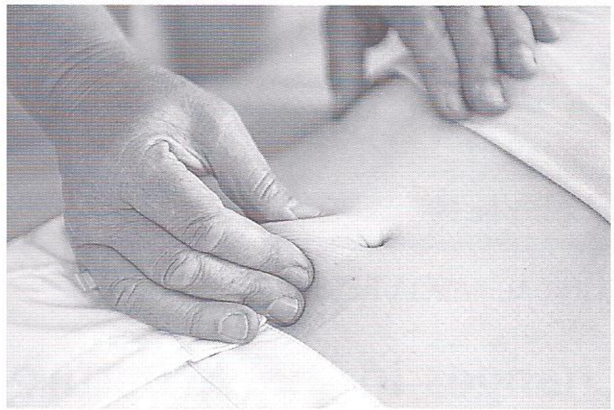

Figure 1 Treatment of the connective tissue of the skin.

Subjects

Thirty patients who came for body therapy, 16 females, 14 males, 23—80 years old. The mean age was 52 years.

Criteria for inclusion

The afflicted area was easy to measure and had no trigger points or muscle tenderness under pressure.

Treatment

Patients were treated in the area of one of their complaints. Treatment lasted for 4—29 min with an average of 14 min.

Method

A Minhorst Collagenoson© was used for measurement. This is a high-resolution high-frequency ultrasound (22 MHz),

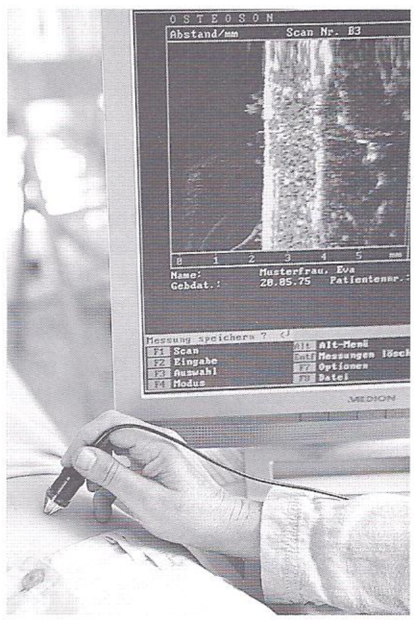

Figure 2 Ultrasound measurement with Collagenoson®.

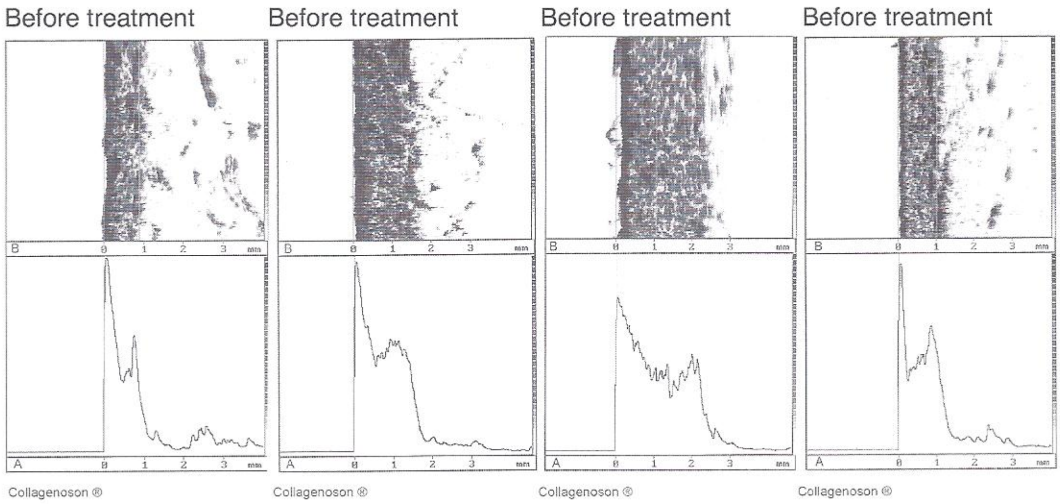

Figure 3 Distribution of collagen in afflicted areas before treatment.

reaching 4 mm beneath the surface. It makes visible objects the size of micrometres, that are dense enough to give an echo, in this case, bundles of collagen. For measurement, a probe is moved along a 2.5 cm path of the skin.

Measurement

Patients were measured immediately before and after their first treatment in one of their afflicted areas.

Results

Figure 3 shows four examples of the measurements obtained before treatment.

In general, the distribution of bundles of collagen fibrils can always be seen as a picture B=brightness scan and a diagram A=amplitude scan. The latter shows the curve of summed collagen density in the various layers of the skin.

The following characteristics of normal skin can be seen in all our subjects:

On the left side of the pictures (in the B Scan), there is always a thin dark band showing the high echo coming from the epidermis. This is regularly the highest peak of the entire curve in the A Scan. On the right is the dermis, which always contains a lot of collagen, which is seen in the B pictures as the high density of dark points and in the A scans as an elevated curve with several peaks. The second highest peaks of the graphs are often seen at the transition from the dermis to the subcutis. In the subcutis on the right side of the pictures, the density of dark points is reduced; consequently, the curve is flatter and the peaks are less high. This reflects subcutis containing markedly less collagen.

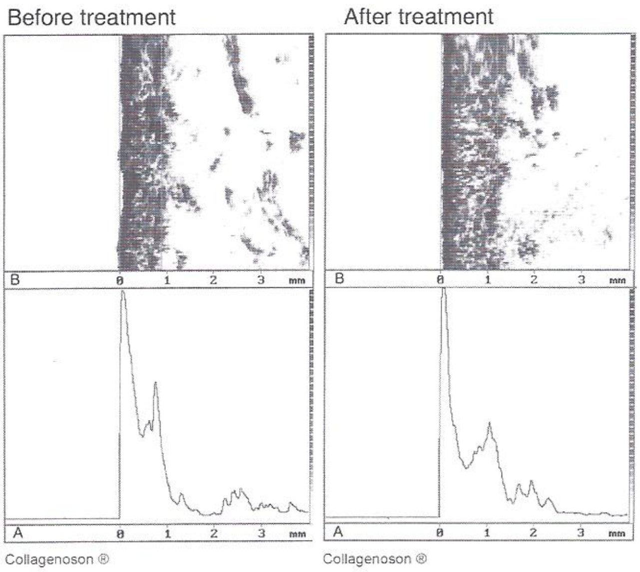

Figure 4 32-year-old female, pain felt in the inferior left abdomen.

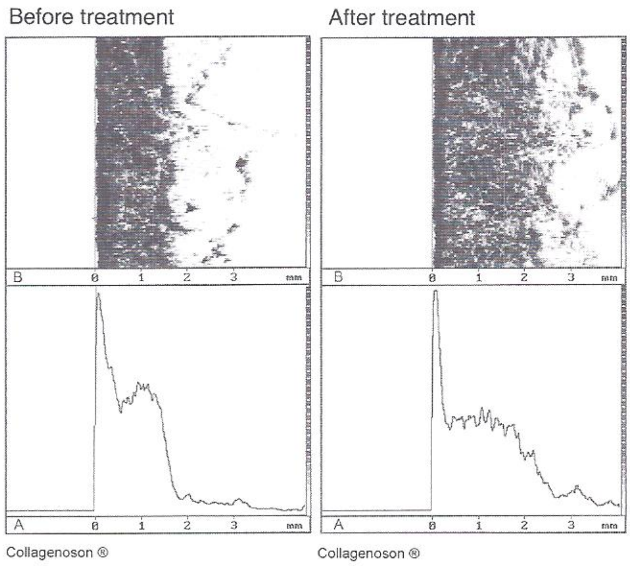

Figure 5 56-year-old male, pain felt at the front of the right shoulder.

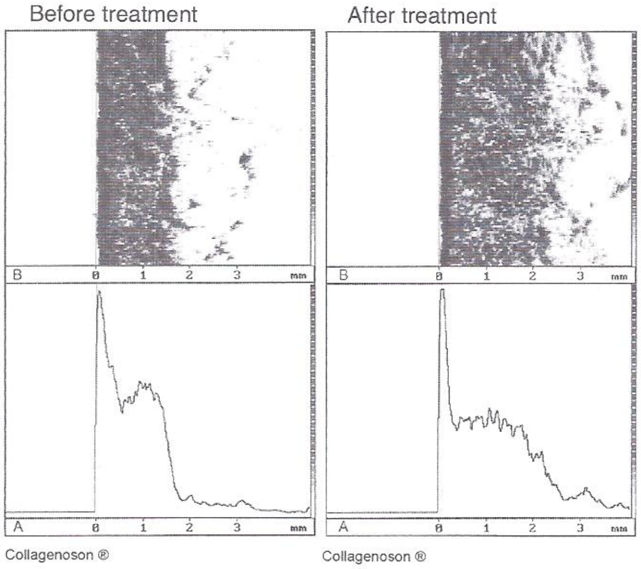

Figure 6 64-year-old female, pain felt on top of the left foot.

Besides these general traits, large differences between the different specimens can be seen.

Thickness of the skin and quantity of collagen are known to depend on the following:

- area of the body (e.g. Smalls et al., 2006)
- gender (e.g. Roberts et al., 1975)
- age (e.g. Roberts et al., 1975; Hall et al., 1981)
- hormonal status (e.g. Quatresooz et al., 2006)
- diseases (e.g. Pitt et al., 1986; Collier et al., 1986)
- medication (e.g. Cossmann and Welzel, 2006)
- mechanical forces (e.g. Kligman and Takase, 1988)
- exposure to sun (e.g. Kligman and Takase, 1988)
- dominance of an extremity (e.g. Smalls et al., 2006)
- and many other factors.

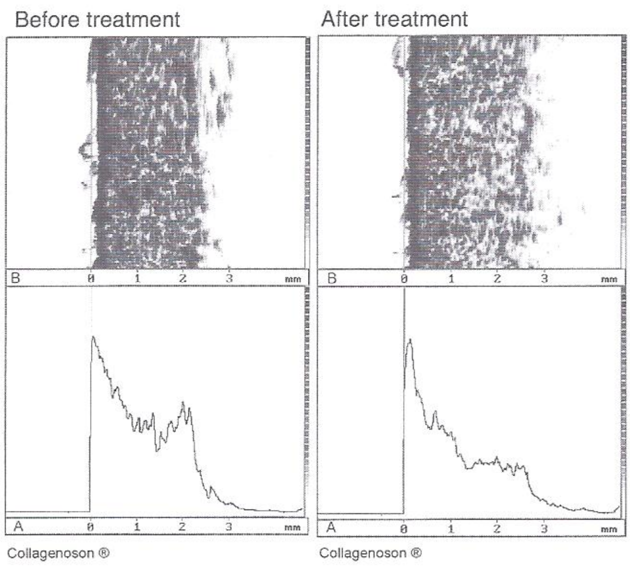

Figure 7 41-year-old female, nausea felt in superior abdomen.

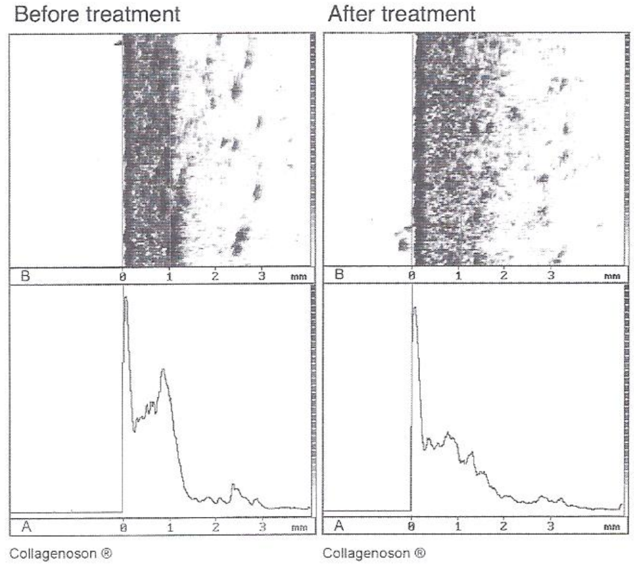

Figure 8 57-year-old male, instability felt in the left calf.

For a summary of factors influencing thickness of the skin, see Krackowizer (2007).

Due to these differences—both by individual and between—there were no baseline data available, no matched control group could be established, and only pre/post comparisons were possible.

Individual pre/post comparisons

Qualitative description of differences before and after treatment

At first glance there is a high congruence of what can be palpated and what the ultrasound pictures show. It looks as it feels.

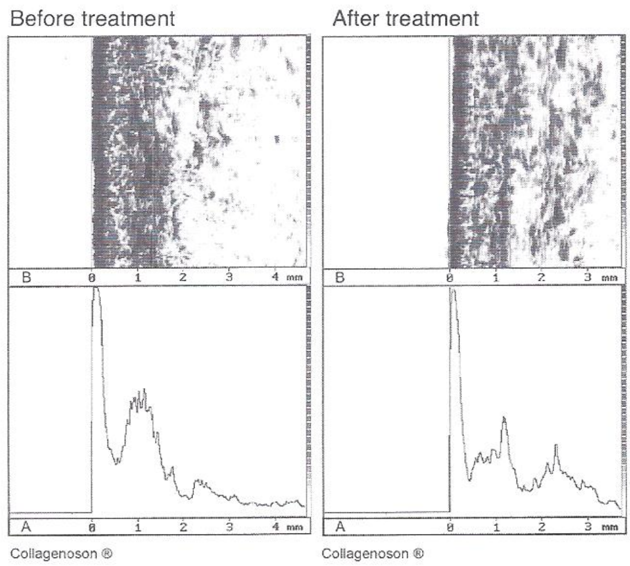

Figure 9 60-year-old female, pain felt on the left tibialis anterior.

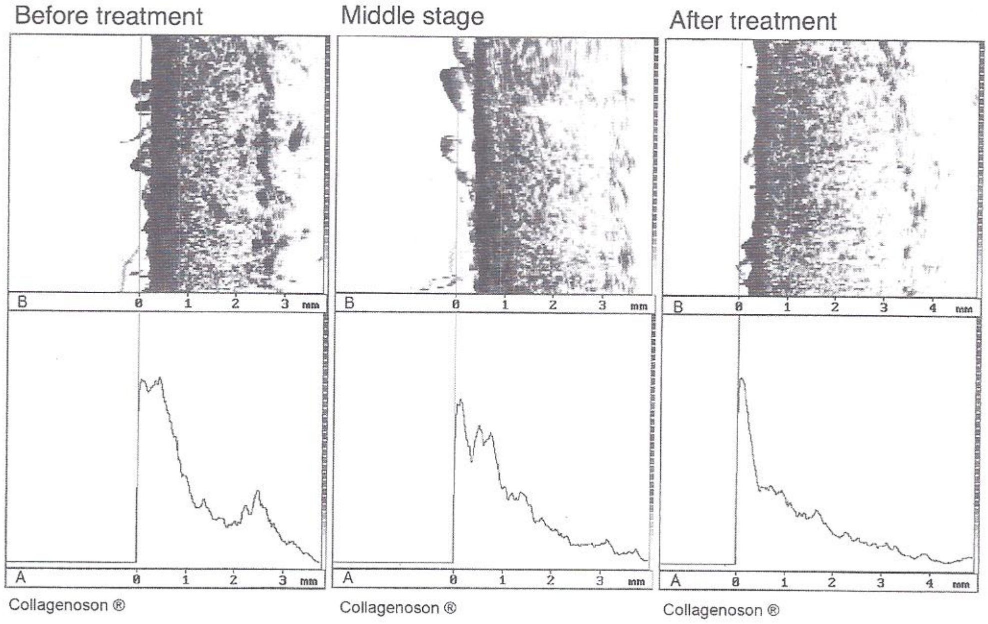

Figure 10 37-year-old female, breathing restriction upper right abdomen.

Epidermis does not seem to change with this sort of treatment (B scan and A scan).

Dermis: After treatment the dermis looks broader. In the B pictures, there seems to be more fluid within the dermis than before and collagen is more distributed in the surrounding fluid. There is a more homogeneous structure with less high densities and a less-marked border to the subcutis. These differences are reflected in the A scans: after treatment the highest peaks in the dermis are lower than before and the curves are smoother.

Subcutis: Since the dermis seems to have broadened and the Collagenoson® measures only at a depth of 4 mm, there is less of the subcutis seen after the treatment. Hence, direct comparisons are not possible.

For a qualitative description of pre/post differences, see Figures 4—9.

In the last example (Figure 10), an extreme densification in the papillary layer of the dermis (next to the epidermis) can be seen, which disappears over the course of treatment.

Statistical analysis and results

For measuring the differences in collagen distribution before and after treatment, two measurements of the A scans (curves) were taken: height of the highest peak in the dermis (second highest peak of the entire curve) and thickness of the skin. Both were measured before treatment (at T1) and after treatment (at T2). Measurement was done by an independent observer.

For the variable height of the highest peak in the dermis, the distance of the highest point in the dermis from the *x*-axis was measured. The difference of the mean height of the highest peak in the dermis before ($M = 3.72$, $SD = .68$) and after ($M = 2.59$, $SD = .55$) treatment was highly

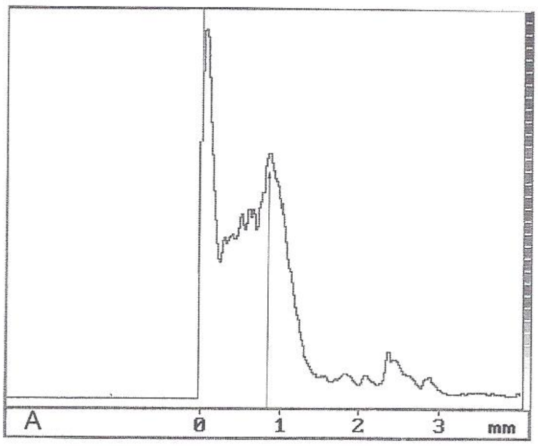

Figure 11 Example for the measurement of the height of highest peak in the dermis.

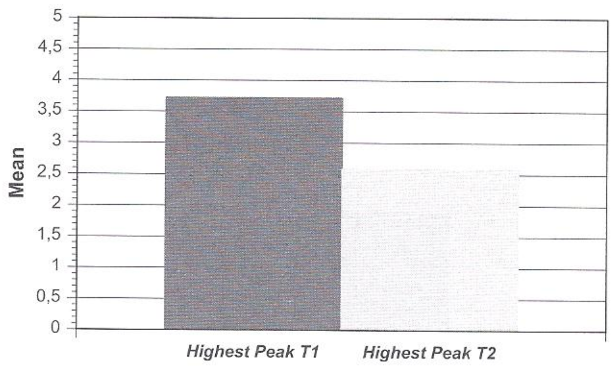

Figure 12 Mean difference in the height of the highest peak in the dermis before and after treatment.

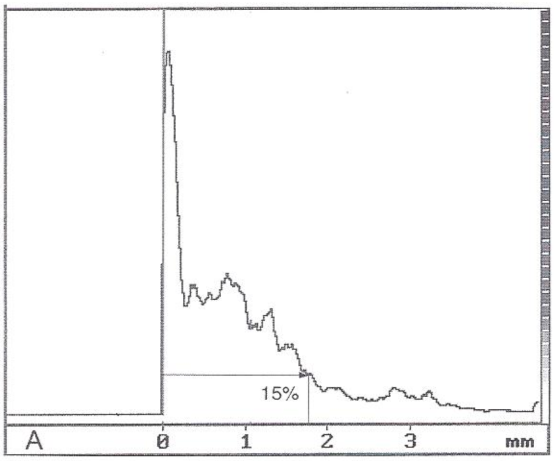

Figure 13 Example of the measurement of the thickness of the skin.

significant (t-test for matched pairs, t-ratio=−8.03, DF=29, $p<.0001$) (see Figures 11 and 12).

No gender or age influence could be found for this variable.

The variable thickness of the skin (epidermis and dermis, without subcutis) was determined as length of the x-axis, where the first time the curve from the y-axis cuts the line by 15% in height. The difference of the mean height of the highest peak in the dermis before (M=1.83, SD=.74) and after (M=2.04, SD=.67) treatment was highly significant (t-test for matched pairs, t-ratio=3.06, DF=29, $p<.01$) (see Figures 13 and 14).

There was a gender and age influence on the change of thickness of the skin. It was not significant for women, whereas the increase of thickness for men was highly significant (see Table 1).

In a more fine-grained analysis, it turns out that only younger female patients (up to 55 years) showed a highly significant change (see Table 2 and e.g. Figures 4 and 7) whereas older female patients remained unchanged. Male patients showed the opposite finding with a highly significant change for older men and a statistical trend for younger men.

Differences in homogeneity before and after treatment are likely, as can be seen from the graphs (B pictures).

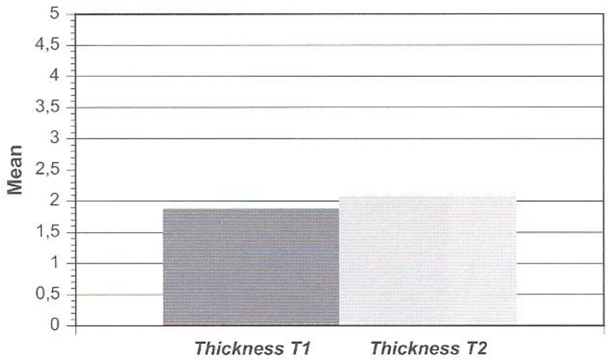

Figure 14 Mean difference in the thickness of the skin before and after treatment.

Table 1 Differences in thickness of skin by gender and results of t-test for matched pairs.

	T1		T2		N	t-ratio	$p<$
	M	SD	M	SD			
Female	2.01	.67	2.08	.66	16	.90	n.s.
Male	1.63	.79	1.99	.70	14	3.52	.01

Table 2 Differences in thickness of skin by age separated for younger and older patients and results of t-test for matched pairs.

	T1		T2		N	t-ratio	$p<$
	M	SD	M	SD			
Younger							
Female	1.94	.62	2.20	.61	6	6.68	.01
Male	1.59	.74	1.93	.48	9	2.21	.10
Older							
Female	2.05	.73	2.00	.70	10	−.50	n.s.
Male	1.71	.94	2.40	1.06	5	4.14	.05

Unfortunately, up to now we do not have a measure for homogeneity to support this observation statistically.

Treatment in non-afflicted areas

As mentioned earlier, we have no real control group, but in 10 cases (six females, four males, mean age 49 years), the same treatment was administered to patients in non-afflicted areas of their skin. There were no complaints in these areas, specimen tissue felt soft from the very beginning and the treatment was not painful. After treatment, neither reddening nor swelling could be seen. No pre/post differences could be found when measuring

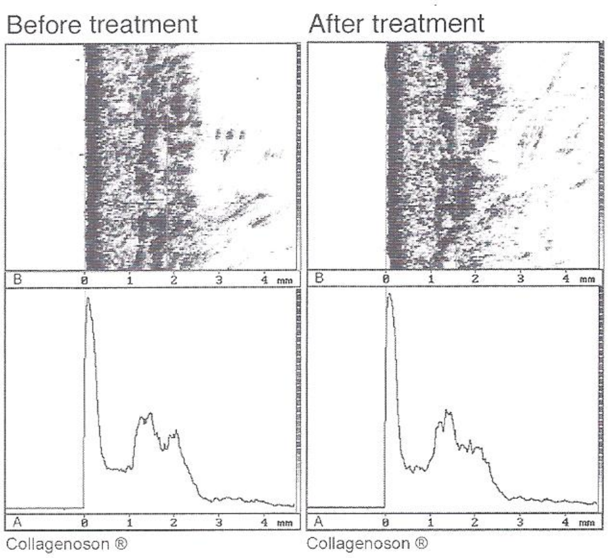

Figure 15 43-year-old male, non-afflicted area (forearm).

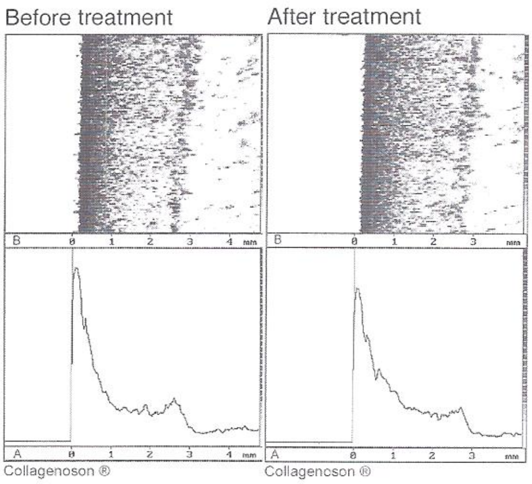

Figure 16 21-year-old female, non-afflicted area (neck).

patients in non-afflicted areas—either in terms of height of the highest peak in the dermis nor in the thickness of the skin (see Figures 15 and 16).

Conclusions

The changes seen in ultrasound scans seem to mirror the differences in tension, density, and homogeneity in the skin, palpable immediately before and after treatment. It looks as it feels.

The main differences in the distribution of collagen that were measured, showed:

- a reduction of the highest densifications in the dermis (found mainly in the transition zone with the subcutis);
- an increase in thickness of the dermis.

To date, we can only speculate about the causes of the changes we could observe. It may be an interaction of two overlapping processes: relaxation of fibroblasts and increase in microcirculation.

Fibroblasts are very numerous in the dermis. A count of dermal fibroblasts produced numbers between 2100 and 4100 mm^{-3} in the midst of the dermis (Miller et al., 2003) and 1×10^6 cells per cm^2 in a 100 μm thickness of papillary dermis, respectively (Randolph and Simon, 1998). Fibroblasts and their dendrites have been shown to form a network (Novotny and Gnoth, 1991) that exerts active mechanical forces in many fascial tissues like subcutis (Langevin and Cornbrooks, 2004; Langevin et al., 2005), muscle fascia (Schleip, 2006), and dermis (Fray et al., 1998; Grinnell et al., 2003). It has also been shown that fibroblasts of the skin are able to contract collagen lattices and that their ability to contract can be changed by various substances (Coulomb et al., 1984; Adams and Priestley, 1988).

Before treatment there may be a contracture of the fibroblasts in the skin, which can be felt as tension in the tissue and may be seen in the echoes of the ultrasound as somewhat higher densities of dermal collagen fibres. This contraction may also exert a pressure on receptors in the skin, causing feelings of discomfort.

The manual treatment of the skin may influence mechanoreceptors, causing processes leading to relaxation of the fibroblasts.

In the transition zone of the dermis to the subcutis and in the papillary dermis, where we found the highest densities of collagen (see Figure 17, right side), there are also the plexus of blood vessels of the dermis (see Figure 17, left side, and Braverman, 2000)—around blood vessels there is the highest concentration of fibroblasts (Randolph and Simon, 1998). Therefore, contracture of fibroblasts may restrict microcirculation. Pericytes may also be involved in this process.

Thus relaxation of fibroblasts may lead to:

- widening of the skin,
- reduction of the highest collagen densities,
- facilitation of movement of interstitial fluid,
- mechanical and chemical changes influencing blood and lymph vessels,
- increased microcirculation and a thickening of the skin.

Relaxation of fibroblasts and increased microcirculation may also lead to the clinical phenomena of:

- less-restricted movement,
- reddening and swelling,
- sensations of softness and warmth,
- feelings of wellbeing.

Further research is needed to find out how long-lasting the immediate changes are and what their contributions to healing processes may be.

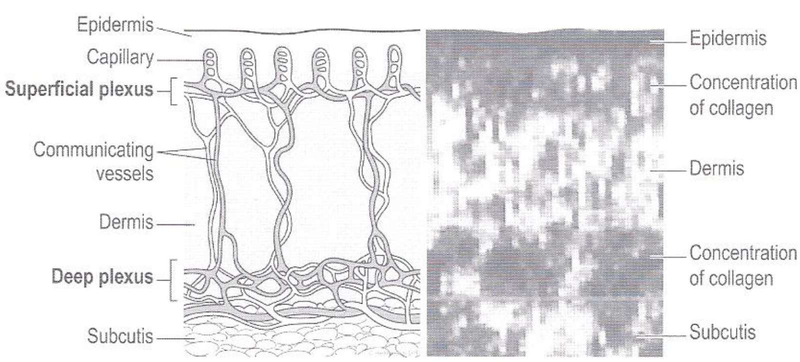

Figure 17 Blood vessels in the skin (left) and collagen distribution (right).

Since every manual treatment directly or indirectly also treats the skin, the connective tissue of the skin should become a focus of scientific attention, especially in functional sensory motor disorders.

Acknowledgments

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