The subacromial impingement syndrome of the shoulder treated by conventional physiotherapy, self-training, and a shoulder brace: Results of a prospective, randomized study

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This prospective, randomized trial was performed to compare the results of treating subacromial impingement syndrome of the shoulder by a guided self-training program with the treatment by conventional physiotherapy or a functional brace. Sixty patients with the diagnosis of an outlet impingement syndrome of the shoulder (Neer I and II) were treated either by strengthening the depressors of the humeral head with a guided self-training program, by conventional physiotherapy, or by wearing a functional brace. The Constant-Murley score was assessed after 6 and 12 weeks. Shoulder pain was monitored with a visual analog scale. All three groups showed a significant improvement in shoulder function as well as a significant reduction in pain. There were no statistically significant differences among the groups. Guided self-training can lead to results similar to those of conventional physiotherapy. The comparable effect of the functional brace remains unclear and might be explained by an influence on proprioception. (J Shoulder Elbow Surg 2004;13:417–23.)

Subacromial impingement syndrome is one of the most common shoulder disorders in adults,[19] with a high socioeconomic impact on working ability.[21] Defects in proprioception and motor coordination of the rotator cuff and the deltoid muscle were recently discussed as playing a major role in the development of subacromial impingement syndrome.[10,14,18,20,21] This is one of the main reasons why physiotherapy is considered to be the first choice in conservative treatment toward improving the balance of centering muscles and strengthening the humeral head depressor muscles.* Increasing cost supports the use of self-training, as recently discussed by Werner et al.[37] There have also been reports on treating subacromial pain with a functional brace,[32] assuming that a brace may relieve subacromial impingement. This concept might also be interesting from the economic point of view.

The aim of this prospective, randomized study was to compare the treatment of the subacromial impingement syndrome, either by conventional physiotherapy, by a self-training program, or by a functional brace.

MATERIALS AND METHODS

After informed consent was obtained, 60 consecutive patients with painful disabling impingement syndrome of the shoulder were randomized into three different conservative treatment groups.

Self-training and centering physiotherapy aim at strengthening the depressor muscles and centering the humeral head and, therefore, probably reduce subacromial impingement. Because the position of the scapula also has a high impact on the width of the subacromial space, the training programs also included the pectoralis minor, trapezius, rhomboids, levator scapulae, and serratus anterior.[8,33] The exercises were chosen according to clinical and electromyographic findings, identifying muscular activity during different movements.[9,24,28,35] For self-training at home, an elastic band (Thera-Band; The Hygenic Corporation, Akron, Ohio) was used because this seemed more suitable than dumbbells.[9,24,28,35] The main advantage of the Thera-Band was the availability of different levels of resistance, so it could be adjusted individually to the patient's level of strength.

Our initial thought behind the use of the functional brace was to have a group of patients whose condition largely corresponds to the natural course of the disease. From the biomechanical point of view, no therapeutic effect was expected, although there are reports of treating subacromial pain with a functional brace,[32] assuming that a brace

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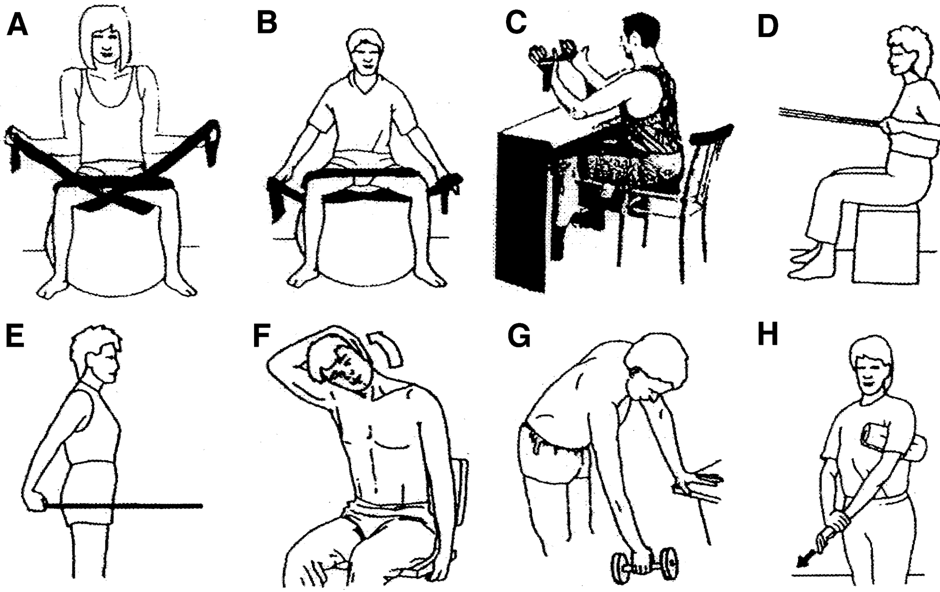

Figure 1 Example of illustrations on handout for a patient undergoing an individual adjusted self-training program. The instructions for each box are as follows: **A**, Sit down, with the upper arms close to the body and the elbows flexed at a right angle. Wrap the Thera-Band around both thighs and both wrists, as shown in the picture. Pull the shoulder blades back and push the sternum forward. Twist the forearms slightly outward. Hold the tension for 8 to 10 seconds. Repeat this exercise 10 times. **B**, Sit on a stool or a therapeutic ball. Wrap the Thera-Band around both thighs. Extend both arms alongside the body, and pull the shoulder blades downward as you push your fingertips toward the ground. Keep arms straight and move them outward 10 cm from the body. Hold the tension for 10 seconds. Repeat this exercise 10 times. **C**, Sit down and place both elbows on the table. Grasp the Thera-Band with both hands, creating slight tension. Then stretch the Thera-Band apart without moving the elbows from the pad. Hold the tension for 10 seconds. Be careful to remain in an upright position during this exercise. Repeat this exercise 10 times. **D**, Sit down or stand up. Grasp the Thera-Band at short length with both hands, creating a good tension. Then stretch the Thera-Band by pulling the shoulder blades together. Repeat the exercise 10 times. **E**, Stand and take one end of the Thera-Band in each hand. Stretch arms downward and pull the Thera-Band backward with both hands, while moving the shoulder blades toward the spine. Push the sternum in a forward and upward direction. Hold the tension for 10 seconds. Repeat this exercise 10 times. **F**, Sit down. Grasp the edge of the chair with one hand and lay the other arm over the head, placing the hand on the ear as shown in the picture. Flex the body in the same direction as the head to create a slight tension in the neck muscles. Hold the position for 15 seconds. Repeat this exercise twice on each side. **G**, Place one hand on the table and hold a 1-kg dumbbell in the other hand, as shown in the picture. Now swing the arm like a pendulum, approximately 10 to 20 cm in various directions. Continue this exercise for 3 to 5 minutes. **H**, Stand. Squeeze a towel under the armpit. Take the wrist with the opposite hand, moving the arm across the front of the body and pulling it softly toward the ground. Hold the tension for 15 seconds. Repeat 3 times.

may decompress the subacromial space by displacing the humeral head distally.

Diagnosis of subacromial impingement was established by clinical examination, radiographs of the shoulder in three planes, and ultrasound.[16,39] The Neer test (subacromial injection of 10 mL pure bupivacaine) was positive in all patients.

Exclusion criteria were concomitant cervical radiculopathy, frozen shoulder, full-thickness tear of the rotator cuff, disorders of the acromioclavicular joint, degenerative arthritis of the glenohumeral joint, calcifying tendinitis, shoulder instability, posttraumatic disorders, and involvement in workers' compensation claims. Twenty of the selected patients were randomly assigned to each of the therapy groups.

Group 1: Standardized self-training

The patients were instructed in a standardized self-training program of centering and stretching exercises that affected the shoulder. The program was set up according to the initial clinical findings. Instructions for the exercise program were printed with PhysioTools software (PhysioTools Sverige, Malmö, Sweden) (Figure 1) and given to patients. For most of the exercises, an elastic Thera-Band (Figure 2) was used that was chosen according to the results of the initial force measurements. The self-training program was taught to patients under the guidance of a physiotherapist for a maximum of 4 sessions. The patients were instructed to do the training program at least 5 times a week for 10 to 15 minutes.

Group 2: Conventional physiotherapy

The patients were given a prescription for 10 sessions of physiotherapy consisting of centering training for the rotator cuff. Stretching was added in case of any limitation of the range of motion at the first examination. Further prescrip-

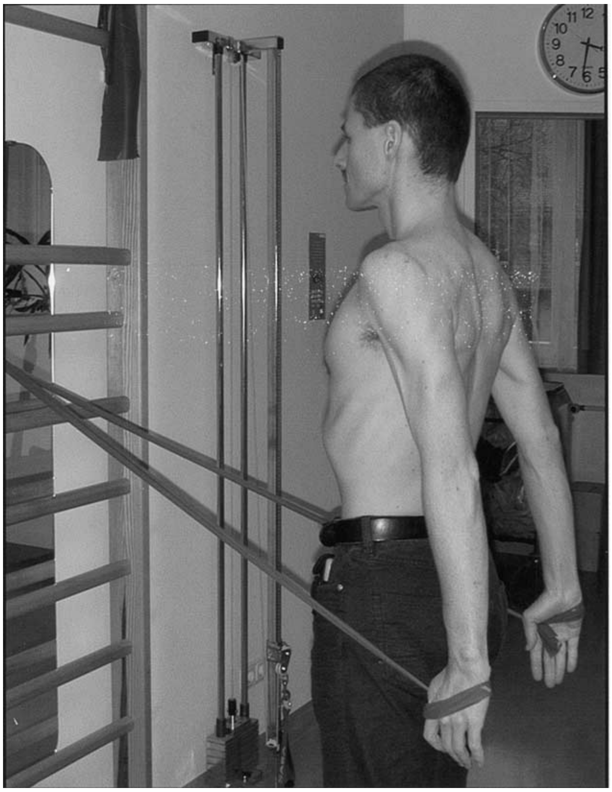

Figure 2 Patient exercising with the elastic band (Thera-Band).

tions were given to patients by their family doctors. The patients underwent physiotherapy 2 to 3 times per week.

Group 3: Functional brace

The patients were supplied with a functional shoulder brace (Coopercare Lastrap; Coopercare Inc, Toronto, Ontario, Canada). They were instructed on how to use the brace and told to use it as long as possible during the day and, if comfortable, also at night. The Coopercare Lastrap shoulder brace consists of a cotton sleeve and special Thermovibe pads. The presumed effect of the brace is the absorption of vibrations and the accumulation of heat. The brace is fixed with two elastic Velcro straps. Indications for the use of the brace are chronic tendinitis, bursitis, overuse injuries, impingement syndrome, and early degenerative arthritis (Figure 3).

All three groups were treated over a period of 12 weeks. In addition to the therapy regimen, the patients were advised to avoid overhead sports and overhead work. After the 12-week period, they were told to use their shoulders normally without any limitation. All patients agreed to conservative treatment. Duration and modalities of prior treatments were recorded: physiotherapy, steroid injections, massage, electrotherapy, and nonsteroidal antiinflammatory drugs.

Shoulder function was assessed by use of the Constant-Murley score,[3,13] which includes pain, activities of daily living, pain-free range of motion, and muscle power. The patients were asked to document pain on a visual analog scale ranging from 0 (pain-free) to 100 (maximum pain). A diary was used to document the frequency of therapy, the frequency of self-training, and the usage of the brace, as well as the inability to work and additional medication.

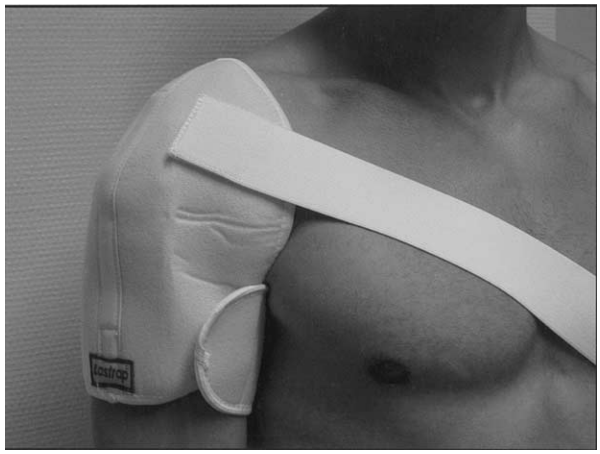

Figure 3 Coopercare-Lastrap shoulder brace.

The patients' conditions were followed up after 6 and 12 weeks. The examination included the Constant-Murley score and the visual analog scale documentation of pain levels. An additional medication (nonsteroidal antiinflammatory drug) was allowed if necessary and was noted in the therapy diary.

Statistical analysis was performed by use of the Link-Wallace test for multiple parametric results. $P < .05$ was regarded as significant.

RESULTS

The statistical analysis of the three therapy groups did not reveal any significant differences in age, duration of disease, pain level, and initial outcome of the Constant-Murley score. Details of the three therapy groups are given in Table I.

Of the patients, 57 (95%) were treated before the study with at least one form of conservative treatment (Figure 4).

The patients in group 1 fulfilled the guidelines concerning the frequency of their exercises. The mean number of therapy sessions after 12 weeks was 30 visits in group 2. The patients in group 3 used the brace for a mean of 12 hours a day. According to the therapy diary, 20% of the patients in each group used nonsteroidal antiinflammatory drugs during the study; however, there was no significant difference among the three groups.

All three groups showed a significant reduction in their pain levels, at night as well as during rest periods and while under stress ($P < .05$) during the study (Figure 5). There was, however, no significant difference among the three groups at any time.

There was a significant improvement in the Constant-Murley score within 12 weeks in all three groups

Table I Age, sex, affected side, and duration of symptoms of three therapy groups

	Age (y)		Sex		Affected side		Duration of symptoms (mo)	
Group	**Mean**	**Range**	**Male**	**Female**	**Dominant**	**Non-dominant**	**Mean**	**Range**
1	52.1	40-66	9	11	12	8	23	3-72
2	51.5	37-66	11	9	11	9	32	2-120
3	48.6	25-61	14	6	15	5	27	5-60

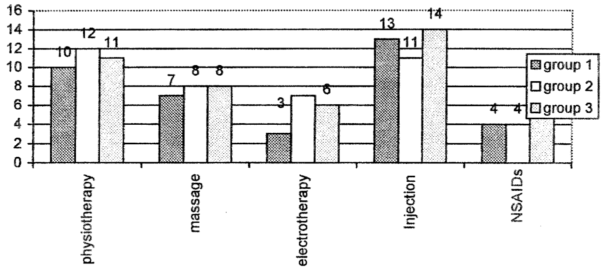

Figure 4 Treatment of the therapy groups before the study. *NSAIDs*, Nonsteroidal antiinflammatory drugs.

($P < .05$); however, the improvement showed no difference among the three groups.

The analysis of isolated items within the Constant-Murley score revealed a significant difference in maximum muscle strength ($P < .05$) (Figure 4). During the first examination, the measurement with the Isobex device (Cursor A.G., Bern, Switzerland) showed a mean of 11.7 ± 6.2 points (10.8 ± 5.9 points in group 1, 12.3 ± 6.3 points in group 2, and 11.8 ± 6.1 points in group 3). The maximum Constant-Murley strength score is 25. After 12 weeks, group 3 achieved a mean value of 14.4 ± 5.4 points, group 2 had a mean value of 10.9 ± 4.6 points, and group 1 had a mean value of 11.8 ± 5.4 points. The difference between group 3 and the other two groups was significant ($P < .05$). All other items within the Constant-Murley scores showed no significant differences among the three groups (Figure 6).

The mean period in which there was an inability to work was 1.2 months in group 1, 1.6 months in group 2, and 1.5 months in group 3, ranging from 1 day to 4 months. There were no significant differences among the three groups.

None of the patients treated with physiotherapy or self-training dropped out of the therapy regimen. However, one of the patients treated with the brace complained about being bothered by the brace at work, especially while working overhead. Another patient had eczema of the skin develop underneath the pads. Both patients continued to wear the brace during the remainder of the 12-week therapy period.

Subacromial pain over a period of 12 months and longer was a negative prognostic factor. Those patients had a 9.9-point lower outcome with regard to the Constant-Murley score than the patients with symptoms lasting less than 12 months (78.2 points vs 68.3 points). The difference was 13.5 points in group 1 (78.6 points vs 65.1 points) and 8.1 points in group 2 (74.4 points vs 66.3 points), which both demonstrated a trend. In the brace-treated group (group 3), the difference was 33.8 points (84.8 points vs 51.0 points), which was significant. We could not find any effect of sex and shoulder dominance on the results. A correlation between results and the acromion type in the outlet-view projection could not be confirmed within our patient group.

DISCUSSION

Three groups with a subacromial impingement syndrome of the shoulder were treated with three different conservative methods: self-training (group 1), conventional physiotherapy (group 2), and functional brace (group 3).

The patients were treated and followed up for a period of 12 weeks. The main reason to limit the study to 12 weeks was that it was impossible to keep standardized conditions over a longer period. Prescribing physiotherapy for a longer time is not allowed by the health insurance system. On the other hand, many patients with guided self-physiotherapy wanted to continue with exercises, but only a few of those with a brace wanted to keep it on any longer.

In the last 10 years, many publications have focused on functional disorders that may result in subacromial impingement. These include occult shoulder instability (instability impingement), imbalance or fatigue of the shoulder muscles, contracture of the posterior joint capsule shoulder, and malposition of the scapula.[12,19,23,36,39] It is widely accepted that subacromial impingement can be caused by narrowing of the supraspinatus outlet,[4-6,26,30,35] either by anatomic factors such as a hooked acromion, osteophytes stemming from the anterolateral acromion (traction spurs), or acromioclavicular joint[25,27,29,34] or by functional mechanisms as found in instability impingement.[12]

Several studies have shown that the results of operative and conservative treatment of subacromial

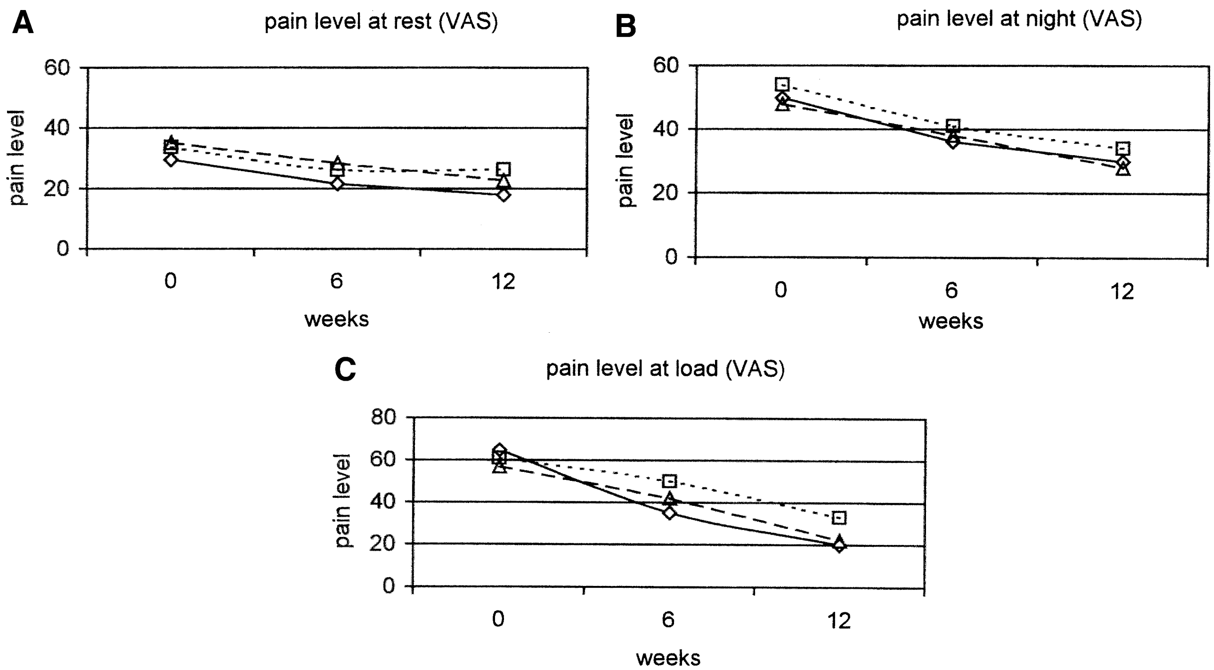

Figure 5 Mean pain level at 0, 6, and 12 weeks, documented with a visual analog scale (VAS) ranging from 0 (no pain) to 100 (maximum pain). *Diamonds*, Brace; *squares*, physiotherapy; *triangles*, self-training.

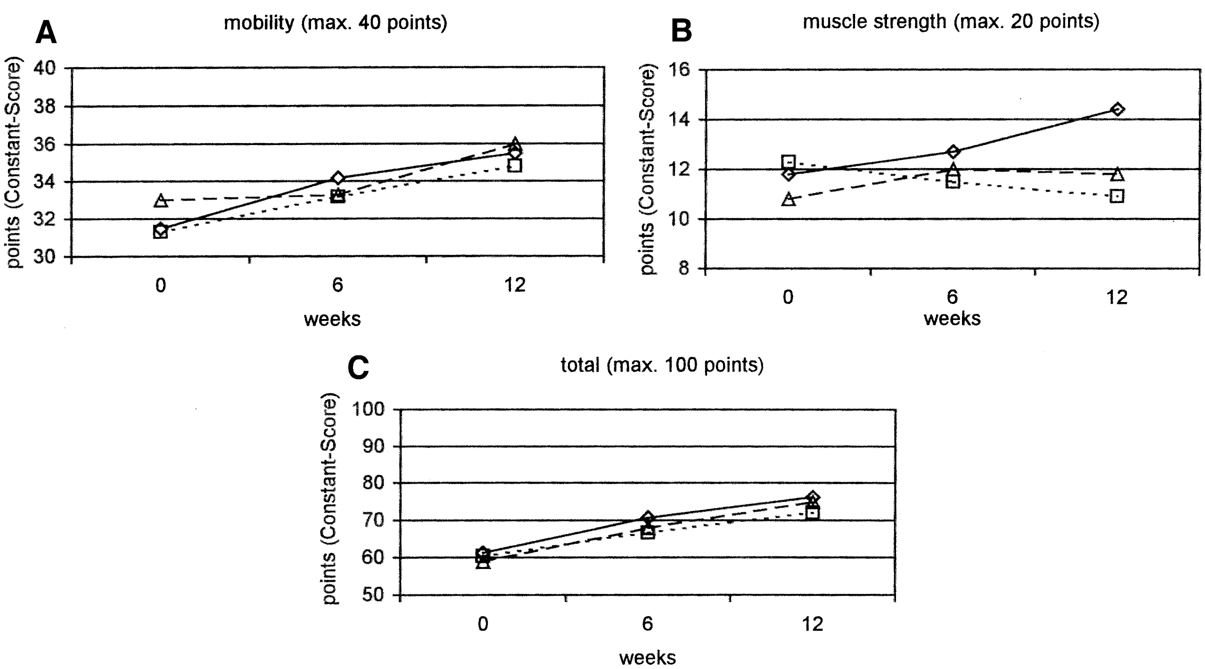

Figure 6 Constant-Murley score. *Diamonds*, Brace; *squares*, physiotherapy; *triangles*, self-training.

impingement without structural defects do not differ substantially.[8,26,30,31] A benefit of guided self-training could be demonstrated by Anderson et al[2] and Loitz et al,[23] who consider guided self-training as a major part of the rehabilitation of subacromial disorders.

All three methods led to a significant improvement in the Constant-Murley score and a significant decrease in pain levels over a period of 12 weeks. The differences among the three groups were small and not statistically significant. This confirms the effect of muscular strengthening of the rotator cuff, either by physiotherapy or by guided self-training. We were surprised to realize, however, that the control group treated with a functional brace achieved results similar to those of the exercising groups, although the concept of centering the humeral head is not accomplished with this treatment.

An analysis of the subitems of the Constant-Murley score showed that the functional brace led to a significant improvement in strength compared with groups 1 and 2. All other subitems did not show any significant difference among the three groups. Initial concerns that the brace may compromise shoulder mobility did not prove to be true (Figure 6).

There is one report on treating subacromial disorders with a functional brace in the literature. Scheuermann et al[32] performed a controlled study in 29 patients with tears of the rotator cuff and another 20 patients with tendinitis of the rotator cuff. The patients underwent physiotherapy and received a shoulder brace (Omotrain; Bauerfeind, Thuringia, Germany). The authors reported a reduction in pain and an improvement in the range of motion after 25 days. After 6 weeks, 40.4% of the patients had a significantly reduced pain level and 29.8% were pain-free at rest. Pain at night was reduced in 51.1%, and 19.2% were pain-free at night. Pain during exercise was reduced in 68.1%, and 6.4% were pain-free. The weak points of this study are a missing control group and the difficulty distinguishing between the effects of physiotherapy and the effects of the brace. Besides these limitations, the findings of Scheuermann et al confirm our results with regard to reduced pain, as well as improvement in mobility and muscle strength.

Comparing the results of the different studies, there is no clear superiority of a particular method.[19,20,22,38,39] The application of the age and sex adaptation of the Constant-Murley score does not change the results—the groups do not differ significantly in those parameters.[11] After 3 months, half of the patients improved by 50% or more.

From the economic point of view, self-training with supervision to a maximum of 4 sessions is superior to conventional physiotherapy with approximately 30 sessions. However, competent instruction, as well as good compliance by the patient, is mandatory. If this cannot be secured, conventional physiotherapy should follow the principles of centering the humeral head. The continuous improvement over time demonstrates that therapy should be continued for at least 12 weeks.

The results of the patients treated with a functional brace raise several questions. Although not following the principle of centering the humeral head, the brace leads to remarkable results. The reason for this may be that each therapy method addresses different pathomechanisms of the impingement syndrome. A statistically significant separation of different subgroups might be possible with a larger population. Another possibility might be that none of the methods influences the spontaneous course of the disease. Given the results of Brox and Brevik,[7] who could show a significant superiority of conservative treatment compared with laser, this theory is very unlikely.

Finally, it might be that all therapy methods have an effect on the same pathology, although the effect of the brace is not fully understood.[1] In this context the increase in maximum strength is remarkable. At the beginning of the study, there was no significant difference among the three groups. Maximum strength did not change over time in groups 1 and 2, but it increased in group 3 up to a significant difference after 12 weeks (Figure 6). The increase in muscle strength can be explained by pain reduction rather than hindrance of excursions within the shoulder joint by the brace. Considering the effect of the brace, one can speculate that the proprioceptive feedback transmitted by cutaneous receptors is enhanced. A reason might be the effects on neuromuscular mechanisms, such as proprioceptive feedback transmitted by cutaneous receptors.[14,15,20] This might improve the neuromuscular control in the movement patterns of the shoulder girdle and scapulohumeral rhythm. It would therefore reduce the probability of a mechanical conflict in the subacromial space. If other studies confirm the positive results, a functional brace might also be an alternative to conventional physiotherapy in the treatment of the impingement syndrome. The main advantage over self-training would be the lower required patient compliance.[17,18,25,27,34]

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