Isolated Paralysis of the Serratus Anterior Muscle

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Introduction

Isolated paralysis of the serratus anterior is an entity that should be more widely understood. Early recognition, followed by treatment that is comparatively simple, although prolonged, usually leads to a satisfactory outcome. The purpose of this paper is to present information pertaining to the clinical picture, anatomy, etiology, and treatment of the condition and to discuss our experience with twenty cases.

Less than 250 cases of isolated paralysis of the serratus anterior have been presented in the literature since Velpeau's first report in 1837. Only two series of more than seven cases have been collected[3, 7]. Fully thirty methods of treatment, many of them surgical, have been advocated. Prognosis has varied from very good to very poor. The explanations of the etiology have differed widely. The sole aspect that many descriptions have in common is the clinical picture.

Clinical Picture

Paralysis of the serratus anterior may come on immediately after a hard blow or after a chronic strain of the neck and shoulder regions. Frequently it may appear insidiously and somestimes even painlessly. In general, howeve, there is first noted an aching or "burning" discomfort of varying degrees of severity in the neck and shoulder, localized vaguely in the region of the scaleni. The pain may radiate down the arm or around toward the scapular area. This is followed, perhaps a day or two later, by inability to raise the arm properly and by winging of the scapula. After the weakness has been well established, the patient complains of a fleeting ache relieved by rest, inability to elevate the arm satisfactorily, and rapid tiring, as well as the deforming effect of a winged scapula.

The fully developed case of paralysis of the serratus anterior shows the classical picture of posterior winging of the scapula. This is usually accompanied by an inability to abduct the arm beyond 90 degrees (Fig. 2-A). During attempts to do push-up exercises or efforts to perform other exercises which require strong anterior scapular fixation to the chest wall, the winging becomes very marked. Generally the shoulder is displaced forward and droops to some extent. There is frequently secondary weakness of

EDITOR'S NOTE: This article is reprinted by permission from the Journal of Bone and Joint Surgery, Vol. 37-A, No. 3, pp. 567-574, June 1955. For this reprinting, we are adding a brief supplement by Mr. Walter Wolfing, C.O., who began work on the brace in 1950 and has worked with the authors since then.

some protagonist muscles, particularly the inferior portion of the trapezius, often accompanied by a tightness, sometimes painful, of certain antagonist muscles such as the rhomboids and pectoralis minor.

Anatomical Considerations

The syndrome is well explained by the anatomy of the long thoracic nerve and its relationship to the serratus anterior. The long thoracic nerve or external respiratory nerve of Bell is almost unique in that it arises directly from the spinal nerve roots, carries no known sensory fibers, and goes to a single muscle of which it is the sole innervation of consequence. It originates from the anterior branches of the fifth, sixth, and seventh cervical roots, except for a few minor variations of this pattern described by Horwitz and Tocantins[4]. The upper two branches of origin pass through the scalenus medius and unite with the third branch just below this point. The nerve then descends under the brachial plexus and down the anterolateral aspect of the chest well, giving off on its way branches to the serratus digitations.

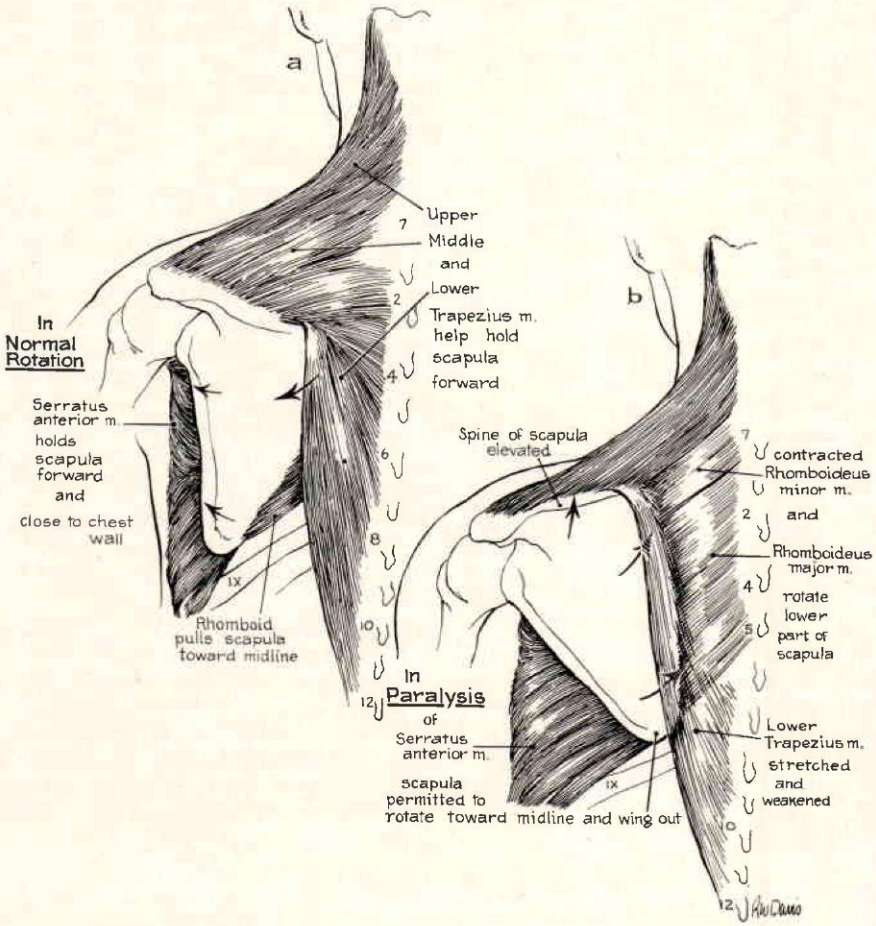

FIGURE 1

Fig. 1, a: Normal position of the scapula at rest. b: In serratus weakness the inferior angle of the scapula rotates backward and upward, stretching the lower fibers of the trapezius. The rhomboids are shortened and contracted.

The serratus anterior is broad and flat; it arises in the form of multiple digitations from the upper eight or nine ribs in the anterior axillary line, and attaches to the deep surface of the scapula along its vertebral border. Its primary function is to draw the scapula forward. This action causes the entire shoulder to be brought anteriorly by a movement at the sternoclavicular joint. The movement of stretching forward, as in fencing, is due to this action of the muscle. Furthermore, by its relation to the inferior angle of the scapula, the serratus anterior causes, along with the trapezius, a rotation of the scapula, which results in a tilting upward of the glenoid cavity, thus facilitating the upward movement of the arm above the head (Fig. 1, *a*).

Etiology

It is difficult to understand how a single muscle extending over such an extensive area and so well protected could be completely knocked out of action by direct trauma without considerable involvement of its neighbors. In an analogous situation, trauma or other irritation to any or all of the three nerve roots, or to the spinal cord, could hardly have such a selective action on only one particular nerve. Therefore, it is reasonable to assume that the pathological condition underlying this lesion is located in the long thoracic nerve itself. The cause of this condition, however, is another and far more difficult matter to explain.

Some cases are indisputably traumatic in origin, beginning immediately after a severe blow, fall, or sudden malforming twist and strain which force the shoulder downward and backward. Others follow more sustained or chronic traumata, such as prolonged carrying of a heavy knapsack, arduous shoveling, strenuous games of tennis, and the like. The marked preponderance of cases occuring on the right side in this series, coupled with the 83 per cent preponderance of those cases in the literature in which the side was noted, may be statistically significant and could provide some clue to the etiology. In a number of cases the condition developed gradually several days or more after operative or obstetrical procedures, perhaps because of cramped positions of physical strain while the patient was under the relaxing effects of anaesthesia. In others it has been reported as toxic in origin after certain infectious or viral diseases. In some it has even followed injection of sera, vaccines, and the more common antibiotics and has been regarded as a sequel to an allergic reaction.

Of 111 cases reported since 1925, thirty-five were attributed to acute trauma, sixteen to recurrent trauma, thirteen to postinfectious conditions, eight to injections, six to postpartum and seven to postoperative complications. Thirteen were of unknown etiology. In addition, Hansson ascribed thirteen cases to exposure to cold. These diverse predisposing factors are very similar to those held responsible for the development of Bell's facial palsy and other single nerve palsies such as those of the radial, peroneal, and axillary nerves. This fact, combined with the similarity of the clinical pictures, recovery patterns, and anatomical relationships, seems to indicate a common pathological picture of nerve trauma or non-specific "neuritis" which links these varied isolated paralyses with isolated paralysis of the serratus anterior.

Examination

The value of a careful muscle examination can hardly be overemphasized, not only in arriving at a proper diagnosis, but in differentiating isolated paralysis of the serratus anterior from other conditions which may resemble is superficially. The clinical picture has already been touched upon. Since the most striking feature is winging of the scapula, tests must be made to

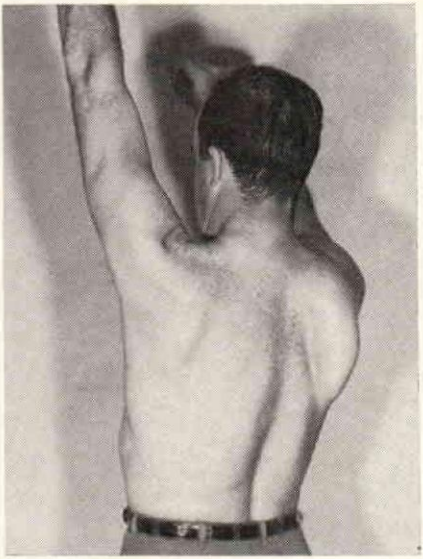

FIGURE 2-A

Fig. 2-A: Paralysis of the serratus anterior on the right. Note the winging and rotation of the scapula. There is inability to abduct the scapula and hence inability to abduct the arm.

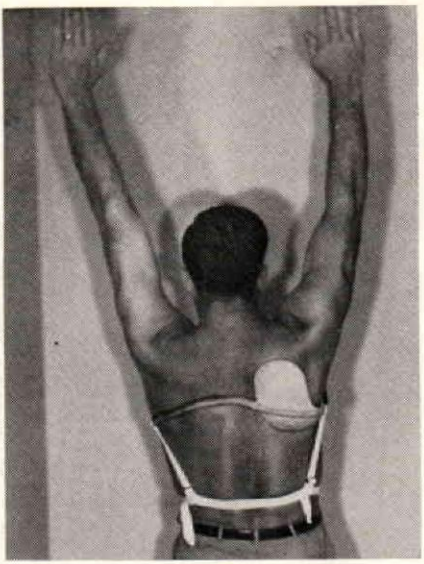

FIGURE 2-B

Fig. 2-B: The brace holds the lower portion of the scapula in forward rotation and abduction and presses it against the chest wall to limit winging; almost complete abduction of the arm is possible.

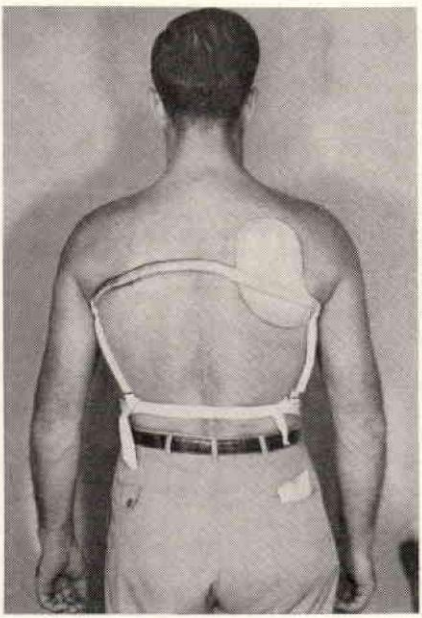

FIGURE 2-C

Fig. 2-C: Photograph showing the brace in a position of rest. The cup fits snugly over the lower two thirds of the scapula, holding it in a position of abduction and preventing drooping of the shoulder or chronic stretch of the serratus anterior.

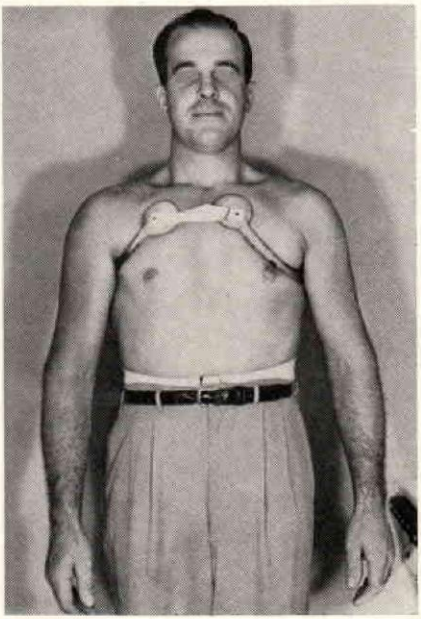

FIGURE 2-D

Fig. 2-D: View of the brace from the front. By counterpressure against the chest wall, the padded disks give firm stabilization of the scapular cup posteriorly.

evaluate the integrity of the serratus anterior and its power to abduct the scapula, to rotate its inferior angle forward against the chest wall and, secondarily, to assist in raising the arm. The simplest method of testing this muscle is to have the patient standing and facing a wall. The arms are outstretched and the palms of the hands are placed against the wall at shoulder level, or slightly above, with the elbows straight, and are pushed hard against the wall. If the muscle is paralyzed, the winging of the scapula will be instantly apparent. There are other confirmatory tests, made with the patient supine and sitting, as described by Kendall and Kendall.

Differential Diagnosis

Differentiating isolated serratus anterior palsy from other conditions requires the taking of a detailed history, and careful muscle check of at least the whole shoulder girdle. Careful examination with an understanding of the pathology of this entity will eliminate neurological disease which has attacked the cord or nerve roots, because in such conditions other weaknesses and neurological changes will be found which conform to characteristic anatomical patterns. Generalized involvements, such as anterior poliomyelitis, combined sclerosis, the dystrophiae and atrophiae, will present spotty or more extensive weaknesses not compatible with secondary adaptation to involvment of a single nerve and a single muscle. A number of the patients herewith presented were referred with erroneous diagnoses ranging from subacromial bursitis to Guillain-Barre syndrome. One patient had had a scaleniotomy and a cervical laminectomy. One of our own cases was at first believed to be unrecognized poliomyelitis, because of the associated weakness of a stretched lower segment of the trapezius. Another patient, on the other hand, was originally considered to bave a bilateral serratus anterior syndrome until a more careful muscle check revealed the lesion to be an early muscular dystrophy of the scapulohumeral type.

Treatment

As has been stated, fully thirty methods of treatment, many of them surgical, have been recommended. When the diagnosis has been made and the anatomy of the condition is understood, treatment should follow rational lines. The long thoracic nerve will recover spontaneously in the great majority of cases in from three to six months. Therefore, during this period, therapy should be directed toward guarding the serratus anterior and its protagonists from overstretching, and toward strengthening these muscles as rapidly as possible. Similarly the contracted and often painful antagonist muscles should be stretched to prevent scapular fixation in the abnormal position.

The use of a shoulder spica, as advocated by Berkheiser and Shapiro, or the elevation and derotation brace method as described by Horwitz and Tocantins are sound procedures but rather severe, as they incapacitate the patient for a number of months. The scapular cup devised by Wolf and used by us in several cases seemed theoretically to be the best ambulatory treatment, as it allowed freedom of both arms. However, we found this brace quite difficult to fit satisfactorily and many patients would not tolerate it. After a number of alterations, a brace has been evolved (Figs. 2-B, 2-C, 2D, and 3) which is light, comfortable, and gives better scapular support than any we have previously used. Its main virtue is that the patients like it and wear it constantly. With it they can lead a normal life, provided that heavy use of the affected arm is not required, yet they seem to get as good support as from a shoulder spica and the results are as good. Its use

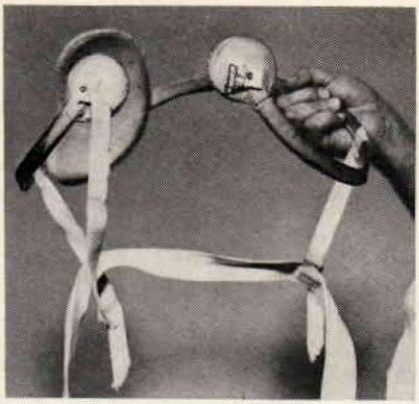

FIGURE 3

The brace itself weighs little over a pound. It is made of tempered, slightly springy brace steel, three-sixteenths of an inch thick and five-eighths of an inch wide. The padded steel cup and the disks are covered by leather. The cup is fitted to the individual scapula, with the patient's arm lying in full passive abduction.

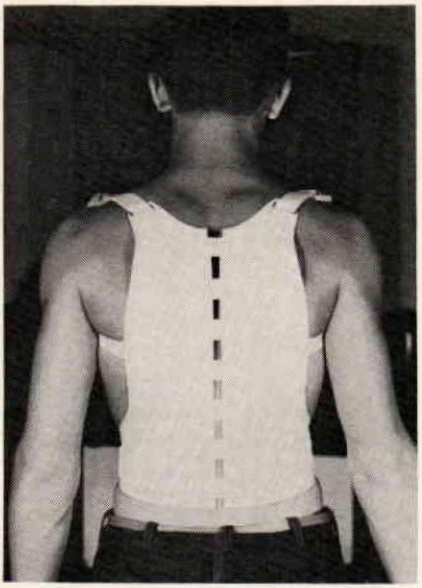

FIGURE 4

Fig. 4: Photograph of the canvas shoulder brace. Heavy steel stays on each side of the back and tight straps across the chest hold the scapula next to the chest wall. The buckle on top of the shoulder can be tightened and tends to derotate the scapula. Adduction of the scapula is not prevented.

is also recommended in other conditions, such as poliomyelitis, in which serratus anterior weakness is a major factor.

Before the brace was perfected we used a reinforced canvas shoulder brace (Fig. 4) in some of the cases with milder involvement; we still recommend its use for the later stages of the condition when tests of the serratus show only slight weakness. This canvas brace partially limits the winging and rotation of the scapula, but obviously cannot prevent the adduction in cases in which the serratus anterior has been severely weakened.

The indications for operation seem meager in a condition in which there is such a relatively good prognosis on a conservative regimen. Some of the cases reported in the literature in which operation was performed seem to have been inadequately or impatiently treated. The fact that several of our patients were seen a year after the onset of symptoms indicates that failure to provide protection will frequently prevent recovery, while institution of protection will promote recovery even at a late date. Many of the good results attributed to operations, such as fascial fixation or muscle transplantations, have been due, it is believed, to the mere reinforcing of a muscle the function of which was already returning. On the other hand, operations seem indicated when there is proved irrepairable damage to the long thoracic nerve, when a thorough and adequate conservative course of treatment has failed, or sometimes when the serratus anterior palsy is part of another disease, such as poliomyelitis.

Enthusiasm for conservative treatment is not to be understood as a condoning of inadequate treatment. Admittedly the course of therapy is long and arduous and requires specialized care. Although only one muscle is originally and primarily involved there is produced a definite effect upon its an-

tagonists and protagonists. Antagonists, such as the rhomboids, relieved of the duty of balancing the normal serratus pull, become contracted and excessively strong. The trapezius, especially its lower and middle thirds, although a competitor as an adductor, is an assistant in the complex rotatory control of the scapula (Fig. 1) and tends to become stretched and weakened. However, it is possible to strengthen the trapezius sufficiently to resist this stretch (Fig. 5) and even to compensate partly for a weak serratus anterior in obtaining full abduction. This strengthening of the lower fibers of the trapezius is one of the major aims in therapy and does much to minimize the continuous elongation of the serratus anterior which so delays its recovery. Patients are cautioned to forego any strenuous activity which abuses the weakened structures. Careful stretching of contracted and often painful antagonist muscles, such as the rhomboids and the pectoralis minor, completes the plan of treatment.

The outline of treatment here presented is a combination of physical therapy and brace protection, which has proved satisfactory in our more recent cases.

Outline of Treatment

For complete paralysis of the serratus anterior: The brace should be worn day and night. Exercises should consist of muscle-setting, exercising the serratus anterior in its function as a forward rotator of the scapula: With the patient supine, the arm is placed overhead, resting on a pillow, and the patient is asked to press the arm down on the pillow (in the direction of completing arm-raising overhead). The tendency will be to press the elbow down toward the table, adducting the scapula. *This should be avoided.* Emphasis must be on bringing the hand and forearm down toward the pillow in the direction of completing shoulder flexion. The patient should be made aware of trying to bring the inferior angle of the scapula forward during this movement and should be encouraged to palpate the serratus anterior with his opposite hand during this exercise. Although abduction of the scapula is a function of the serratus anterior, exercises involving abduction of the scapula are avoided because of the frequency of associated trapezius weakness.

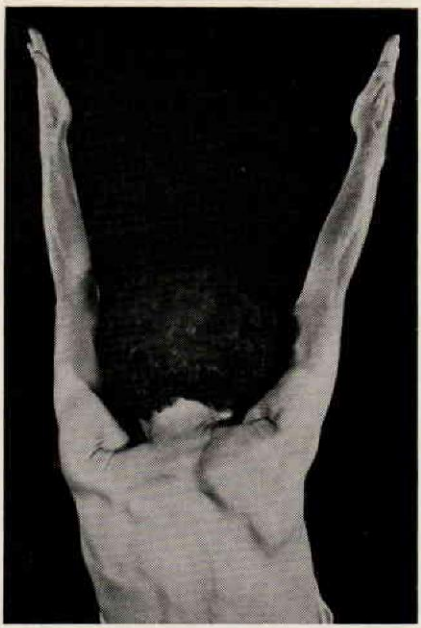

FIGURE 5

Fig. 5: Photograph of a patient with serratus anterior palsy but with strong lower trapezius fibers which prevent backward rotation of the lower border of the scapula on abduction and allow full movement. (Reproduced by permission from "Muscles, Testing and Function," by Henry O. Kendall and Florence P. Kendall, p. 127, Baltimore, The Williams and Wilkins Co., 1949.)

For moderate weakness of the serratus anterior: The brace should be worn during the day, but not necessarily at night. Exercise: With the patient supine, the therapist flexes the arm slightly beyond 90 degrees, the patient is instructed to continue to elevate the arm and at the same time

press it toward the table against slight resistance. The amount of resistance should be dependent upon the ability of the patient to bring the inferior angle of the scapula forward in the normal rotation action of the serratus anterior. This exercise also helps to strengthen the lower fibers of the trapezius. (If the superior angle of the scapula rotates backward instead of forward, the resistance is too great.)

For slight weakness of the serratus anterior: Weakness may be considered slight when the patient is able to raise the weight of the arm in movements requiring scapular fixation, but is unable to take resistance or to lift any additional weight. The canvas brace or the metal brace should be worn during any activity which requires lifting a weight with the affected arm. Exercises are done in a sitting or standing position, the weight of the extended arm being raised forward in flexion through full range to complete overhead elevation.

For tightness of shoulder adductors: With the inability to raise the arm through a full range of motion, the problem of adaptive shortening of the shoulder adductors may be encountered. If examination reveals a limitation of motion in passive raising of the arm overhead, treatment should be directed toward maintaining normal length of these muscles. Heat and massage should be applied to the shoulder adductors. Passive stretching of the arm in overhead elevation should be done by the therapist to avoid strain on the weak serratus anterior, and it is preferable that the patient be supine on the treatment table in order to keep the scapula braced against the table and to avoid winging of the scapula.

For tightness of the rhomboids: The rhomboids, being direct opponents of the serratus anterior, tend to shorten. There may be pain in this region, associated with the muscle tightness. Heat and massage should be applied to the rhomboids. The arm should be be raised passively overhead while pressure is applied along the vertebral border of the scapula, bringing the inferior angle of the scapula through the normal range of forward rotation.

Material and Results

Twenty cases of isolated paralysis of the serratus anterior are herewith presented and analyzed. Of these, seventeen have had the benefit of complete examination of the muscles of the involved shoulder girdles and arms and twelve have had repeated muscle examinations. The right side was involved in eighteen cases, the left side in two cases. The ages of the patients ranged from nine to fifty years, the average being 32.7 years. The sex distribution was evenly divided. The duration of symptoms at the first visit was from one week to one year, the average being seventeen weeks. The etiology, in so far as it could be determined, was recorded as follows: acute trauma, two; chronic trauma, five; postpartum complication, one; postinfectious complication (generally diagnosed as "virus"), three; postinjection complication, four (tetanus antitoxin, two; penicillin, two); and no known cause, five.

Strength of the serratus anterior at the first visit ranged from 0 to 30 per cent., with an average of 10 per cent.; at the third month, it was from 45 to 60 per cent., with an average of 50 per cent., in eight recorded cases; at the sixth month, strength of the serratus anterior was from 70 to 100 per cent., with an average of 85 per cent., in ten recorded cases. In seven cases, follow-up was incomplete or the lesion was to recent for evaluation.

The associated trapezius strength was as follows: upper trapezius fibers, average 100 per cent.; middle and lower trapezius fibers, average 65 per cent.

Associated rhomboid and pectoral tightness was noted in thirteen cases and was not mentioned in seven.

Treatment was by the scapular cup type of brace in eleven, by canvas shoulder brace in six, and by physical therapy and sling alone in three.

At six months the relation of treatment to the end results could be evaluated as follows: In six patients treated with the scapular cup type of brace, the average serratus anterior power was 90 per cent.; in two patients treated with the canvas brace, the average serratus anterior power was 80 per cent.; and in two patients treated by physical therapy alone, the average serratus anterior power was 85 per cent.

NOTE: The authors wish to acknowledge with gratitude the technical assistance of Mr. Walter Wolfing in the construction of the scapular cup type of brace.

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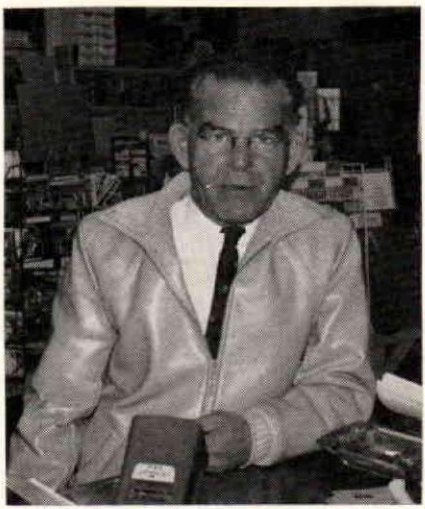
Addendum

Comments on the brace by WALTER WOLFING, C.O., *Baltimore, Maryland*



WALTER WOLFING, C.O.

My experience with this Serratus brace dates back to 1950 when I made the first one at the Children's Hospital School in Baltimore. It was developed because we had found that attaching a scapular pad to a conventional back brace did not hold the scapula in place.

The brace is composed of a metal band around the thorax, one scapular pad (unless there is bilateral involvement), two sternal pads, a webbing waist band, one or two webbing straps from the thoracic band to the waist band, and a strap between the sternal pads.

The thoracic band is made of spring steel 3/32 by 9/16. The scapular pad is made of 0-64 semi-hard aluminum, and is padded only with quarter-inch felt. The sternal pads, also made of aluminum, are two inches in diameter, and well padded with foam rubber and quarter-inch felt. The entire brace is covered with horsehide. Plastic is not used because it is slippery and will not adhere to the skin.

Measuring and Fitting the Brace

With the patient standing with arms down at his sides, the scapula on the affected side will usually protude somewhat and the outline of the scapula can be seen quite easily. If not readily seen, ask the patient to put his hands on his hips.

With the patient in this position, cut a paper pattern of the scapula, allowing about ¾" extra width along the vertebral border. This extra width will allow for cupping the finished metal pad over the vertebral border.

After the aluminum pad is made from the pattern it is necessary to change the position of the arms before molding the pad into its final contour. The arms are now placed overhead, clasping arms by grasping the opposite forearm and resting the forearms on top of the head. This position of the arms brings the scapula into a position of abduction and outward rotation of the inferior angle. In this position the thoracic band is measured and molded in order that freedom of the scapula will be permitted for arm raising. The thoracic band must fit snugly in order to keep the scapula firm against the posterior rib cage. The scapular pad is molded to conform to the body contour. Before attaching the pad to the thoracic band, the brace fitter passively (that is, no help from the patient) lowers the affected arm very slowly and observes the moment the scapula begins to protrude. The arm should be stabilized in this position while the pad is placed on the thoracic band and marked for attachment to it. Finding this position of the scapula is necessary in order that the cupping over the vertebral border will grip the scapula and keep it from slipping back in adduction and inward rotation. The felt padding acts to carry the scapula slightly forward from this position and into more abduction and outward rotation.

The sternal pads must offer sufficient counter-pressure to maintain the scapular pad and scapula firm against the rib-cage. For this reason, these sternal pads must be large enough and well enough padded to avoid the soreness which otherwise would result from the localized areas of pressure.

We have made the brace over the past fourteen years and now average from four to five braces a year. Orthotists who are interested in any additional details are invited to communicate with Mr. Walter Wolfing, Walters Brunos Orthopedic Appliances, 907 North Calvert Street, Baltimore, Maryland 21202.