

## Recurrent thoracic outlet syndrome

Erdoğan Atasoy, MD<sup>a,b</sup>

<sup>a</sup>*Department of Surgery, University of Louisville School of Medicine, Louisville, KY*

<sup>b</sup>*Kleinert, Kutz and Associates Hand Care Center, PLLC, Suite 700,  
225 Abraham Flexner Way, Louisville, KY 40202, USA*

Recurrent symptoms of thoracic outlet syndrome (TOS) can occur following first rib resection or scalenectomy. A 15%–30% rate of recurrence has been reported no matter what type of surgical procedure is performed for TOS. During the scalenotomy era (1927 to the early 1960s) the rate of recurrence was as high as 50%–60%. Since the reintroduction of the first rib resection in the early 1960s and later the scalenectomy in 1979 and with the use of improved techniques the recurrence rate has decreased to as low as 15%–20% [1].

Using a combined transcervical scalenectomy and transaxillary first rib resection approach, recurrence as low as 5% has been reported [2]. A recent review of cases performed in the author's institution confirms that a reversed combined approach [3], first transaxillary first rib resection followed by immediate transcervical anterior and medial scalenectomy, is one of the best procedures to decompress fully the thoracic outlet area and reduce the rate of recurrence. The author's combined approach cases have shown a 95% improvement, with only three cases requiring secondary surgery because of recurrent symptoms [3].

Since the early 1980s the number of patients who complain of upper back and extremity pain with numbness and paresthesias has increased gradually. This is because of an increase in cumulative trauma disorders caused by work environment, especially computer terminals, switchboards, assembly lines, and other working conditions requiring an excessive amount of repetitive, strenuous work. The increasing number of neck and other upper extremity trauma injuries

at the work place and in car accidents also has contributed to this problem. On these patients, generally neck, shoulder, elbow, and wrist pain are diagnosed as cervical strain and a type of tendonitis. Many of these patients have symptoms of TOS and will be diagnosed with it, and nearly one-third of them require surgery. Approximately 20%–25% of these patients develop recurrent symptoms, and an average of 13% of the patients with recurrent symptoms require reoperation. Sanders reported 19% reoperation following transaxillary first rib resection, 14% reoperation after anterior and middle scalenectomies, and 6% reoperation following combined scalenectomy and first rib resection [1]. Many patients diagnosed with TOS also have peripheral nerve compression symptoms (40%–50%) [3]. These include carpal tunnel, cubital tunnel, pronator teres, and, less commonly, radial tunnel compression with epicondylitis.

Some of these patients also experience ongoing symptoms of intractable upper back myofasciitis despite total decompression of the thoracic outlet area. Most patients experience improvement of their arm symptoms immediately after thoracic outlet decompression, but several of them continue to experience upper back myofasciitis with pain and spasms even after moderate extremity activity. Trigger point injection provides temporary relief for these patients, lasting from several hours to several days and weeks. Almost 90%–95% of patients with TOS have upper back myofascial trigger points [3]. This close association is a subject for more thorough investigation.

So called double and even triple crush lesions are common in TOS [3,4]. Proximal nerve compression interferes with axonal transport and

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*E-mail address:* [bstewart@kleinertkutz.com](mailto:bstewart@kleinertkutz.com)

this may lead to a disturbance in the distal part of the axonal membrane composition that makes the axon less resistant to external compression. Reverse double crush lesion also can occur. This explains how a carpal tunnel release sometimes improves proximal nerve compression [3]. Most of the time these peripheral nerve compressions can be diagnosed with a thorough physical examination and often can be confirmed by electromyogram and nerve conduction studies.

Complaints along the distal nerve distribution can be an early sign of TOS, especially in young working women. For this reason it is important for surgeons who perform TOS surgery to have a thorough knowledge of peripheral compression symptoms. They should even be able to do the procedures to correct peripheral compression, either before or after TOS surgery, rather than referring these patients to other physicians.

#### **Definition and prevention of recurrent TOS**

Recurrent symptoms occur when excessive scar tissue builds up around the brachial plexus, causing adhesions between the nerves and the surrounding structures, including the remaining portion of the scalene muscles, a remnant of the first rib, and the chest cage. Recurrence may also occur if the scalene muscles reattach to the remaining portion of the first rib or to the bed of the first rib.

Beginning active and passive exercises very early postoperatively (the day after surgery) is key to preventing recurrence. The patient should perform vigorous active and some passive range of motion exercises with the neck, together with shoulder shrugging exercises, including full abduction of the shoulder, every 2–3 hours at least three to four times in each direction. Patients usually are given postoperative exercise instruction forms and taught how to perform the exercises well before surgery. They are strongly encouraged to practice the exercises before the operation. These exercises minimize the harmful effects of the scar formation on the neurovascular structures by stretching the scar tissue and promoting very early gliding of the brachial plexus and the subclavian artery and vein. The patients should continue these exercises at least six times a day for the next 6–12 months [3].

#### **Treatment of recurrent TOS**

The primary surgical procedures used for TOS generally are considered difficult, demanding, and

high-risk whether the procedure used is first rib resection, scalenectomy, or a combined approach. The surgical procedures that are available for recurrent TOS are even more difficult, more demanding, and riskier than the primary operations.

The management of the patient who has recurrent symptoms of TOS should start with conservative treatment similar to primary TOS, and it should include several physical therapy modalities, medications (muscle relaxants, analgesic soothing creams, and liniments), trigger point injections, and job requirement modifications. If surgical treatment is necessary as a last resort, the type of surgical intervention required depends on previously performed procedures.

In many recurrent TOS cases, although several patients experience mainly lower plexus involvement type of complaints (C8–T1), namely numbness and tingling along the ulnar nerve distribution, in many cases it is difficult to pinpoint the area of involvement. This is because of a variety of other complaints, such as less numbness and tingling in other fingers, widespread pain, extremity weakness and coolness, upper back pain, pectoral area pain, and headaches. For this reason, after complete re-evaluation of the patients' condition, they most likely will require a combined approach to get the best possible result by reoperation.

These patients should be treated mainly with a transaxillary procedure that involves the removal of the remaining posterior portion of the first rib (if it is more than 1 cm) with external neurolysis of the lower brachial plexus, vasolysis of the subclavian artery and vein, and possible removal of most of the second rib especially if it is highly positioned (Fig. 1).

If the patient has not had a scalenectomy, the transaxillary operation for removal of more than a 1-cm long first rib should be followed by a transcervical procedure at the same setting, such as an anterior (removal of 80%–90% of the muscle) and middle (removal of 40%–50% of the muscle) scalenectomy with decompression of the entire brachial plexus (from C5 to T1). If the patient has had a scalenectomy, re-exploration of the brachial plexus, removal of any remaining anterior and middle scalene muscles, and external neurolysis of the brachial plexus (C5–T1) is necessary.

The combined transaxillary and transcervical approach completely decompresses the thoracic outlet area in primary cases and in recurrent TOS. In many patients who have had primary TOS surgery, transaxillary first rib resection is not

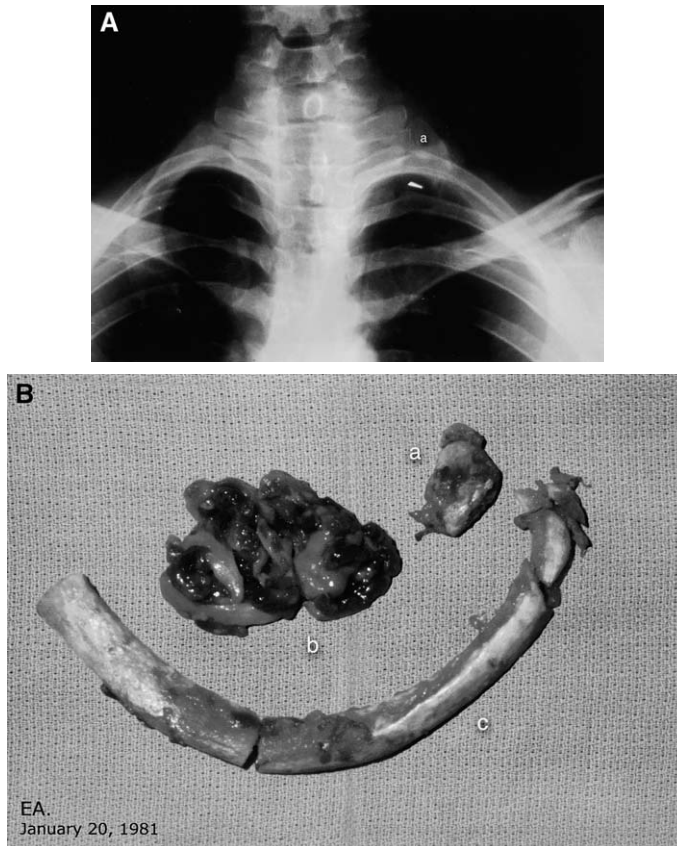


Fig. 1. This female patient had a left transaxillary first rib resection. She developed marked recurrent symptoms of lower type (C8–T1) TOS 6 months after surgery. (A) Radiography reveals 1-inch remaining left first rib posteriorly (a). (B) Patient had reoperation that consisted of transaxillary resection of the remaining 1-inch first rib (a) and middle scalene muscle (b) with external neurolysis of the lower brachial plexus and vasolysis of subclavian vessels. Most of the second rib (c) also was removed at the same time. The patient had very good relief of symptoms. (From The Christine M. Kleinert Institute for Hand and Microsurgery, Inc.; with permission.)

sufficient to resolve the scalene abnormalities in the neck. The author has observed numerous scalene muscle abnormalities while performing the transcervical approach after a completed transaxillary first rib resection.

An exception to using this approach would be a patient who is experiencing strictly recurrent lower plexus compression symptoms and has a sizable first rib remaining posteriorly (Fig. 2) and a patient with only recurrent upper plexus involvement who has had an adequate first rib resection. In these patients the transaxillary approach must be used for cases with strictly lower plexus involvement and the transcervical approach must be used for patients with strictly upper plexus involvement to produce successful results from the secondary procedure.

In some cases of primary and recurrent TOS, sympathetic overactivity can be an associated problem, and in some patients it can be severe enough to require an additional procedure. In those cases, upper extremity sympathectomy can be performed as an adjunctive procedure during the transaxillary approach for recurrent TOS.

In patients who did not experience any or very minimal relief after initial surgery (a group with persistent TOS symptoms), the continued symptoms usually are caused by (1) inadequate removal of the first rib (more than 1 cm remaining), (2) a remaining cervical rib, (3) incomplete removal of scalene muscles and bands (Fig. 3), (4) a second rib being removed by mistake instead of a first rib, or (5) the removal of the first rib with a remaining cervical rib of more than 1 cm in length (Fig. 4).

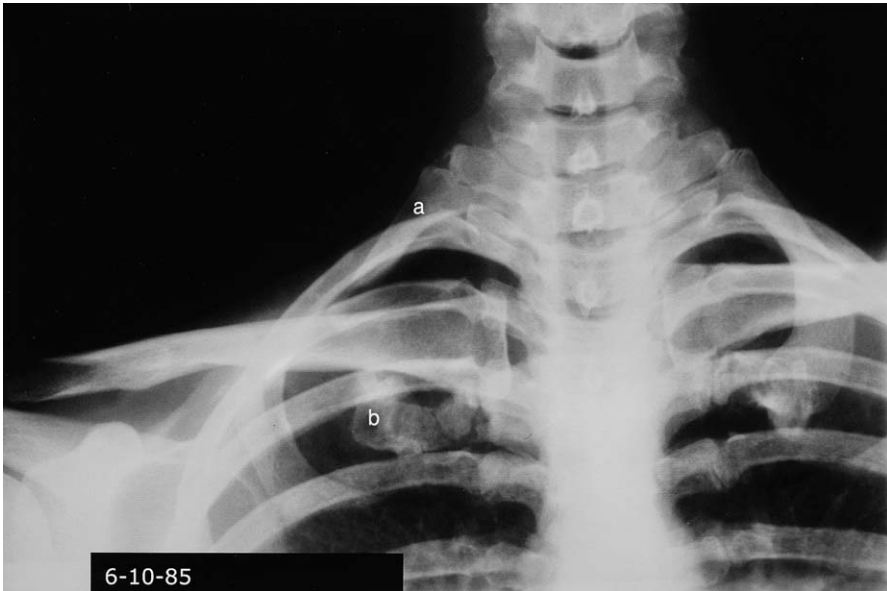


Fig. 2. This female patient had only one third of the middle section of the right first rib removed. She had no relief of her lower type TOS. Radiograph shows 1.5-inch long right first rib remaining posteriorly (a) and 1-inch long anteriorly (b). (From The Christine M. Kleinert Institute for Hand and Microsurgery, Inc.; with permission.)

In addition, an error in diagnosis may have been made and another problem may be the underlying cause of the symptoms.

Once secondary surgery has been performed it is essential to start early active and some passive exercise the next day after surgery to minimize the harmful effects of scar formation and promote very early gliding of the brachial plexus and subclavian artery and vein.

### Results of treatment for recurrent TOS

In the true recurrent group, symptoms develop several weeks or months after the primary surgery, and the main reason for recurrence is formation of excessive scar tissue around the brachial plexus and subclavian vessels.

Sanders [1] reported his results in 134 operations using the transaxillary and transcervical approach on 97 patients over 22 years. He reported an 84% success rate within the first 3 months after various surgical procedures for recurrence. The success rate decreased to 59% after 1.5 years postoperatively, 50% after 3–5 years, and 41% after 10–20 years.

Urschell [5], who used the high dorsal thoracoplasty approach on 225 patients requiring reoperation, reported a 79% improvement rate

over 2 years, a 14% rate of continuing mild symptoms, and a 7% failure rate.

Roos [6] reported his results in 207 operations on 151 patients who had recurrent symptoms of TOS. Depending on whether the level of involvement was in the upper (C5–C6–C7) or lower plexus, either the transcervical or transaxillary approach was used, respectively. In recurrent cases that involved both levels of the plexus, a combined approach was used. He reported that 82% of patients experienced significant relief (excellent to good) and 18% experienced fair to poor relief.

### The author's experience

From 1978 to the end of 2002 (24 years), 208 procedures were performed for recurrent TOS. In all of these recurrent cases, either the transaxillary, transcervical, or a combined approach was used at the time of the primary operation. These patients have been categorized in two groups. In the first group, the recurrent symptoms occurred after a single procedure was performed, whether it was a transaxillary first rib resection or a transcervical scalenectomy procedure. In the second group of patients, the recurrent symptoms occurred following a combined procedure (transaxillary first rib

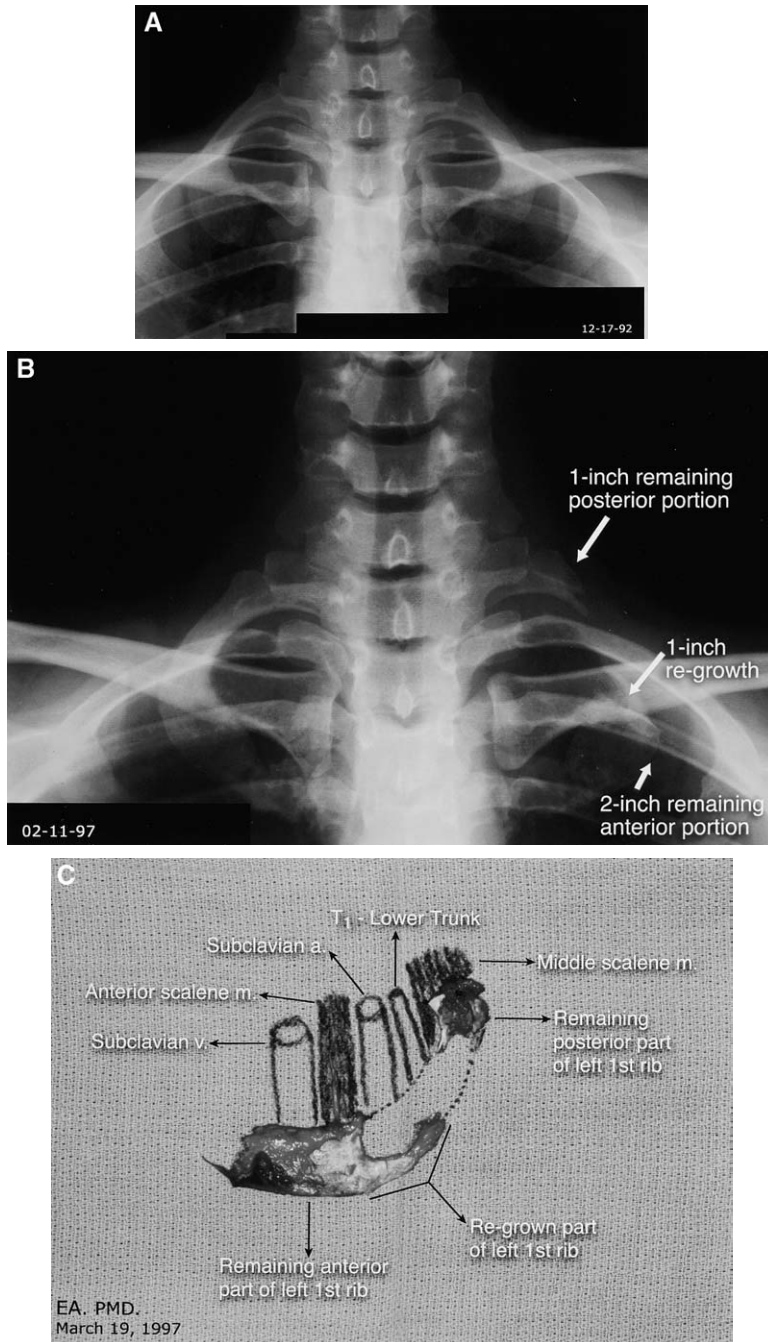


Fig. 3. This 34-year-old female patient had a left first rib resection using the transaxillary approach. Very little of the left first rib was removed and she did not experience any relief of symptoms. (A) Radiograph before the first surgery. (B) Radiograph after the first surgery shows 1-inch remaining posterior portion of the left first rib and nearly 2-inch remaining anterior portion of the left first rib with a regrowth of approximately 1-inch long sharp spike. (C) Surgical specimen of removed remnants of left first rib with schematic representation of related scalene muscles (the anterior muscle was found to be completely intact and the middle scalene muscle had been partially divided at the first surgery), subclavian vessels, and T1 lower trunk. This patient had little improvement of her symptoms. (From The Christine M. Kleinert Institute for Hand and Microsurgery, Inc.; with permission.)

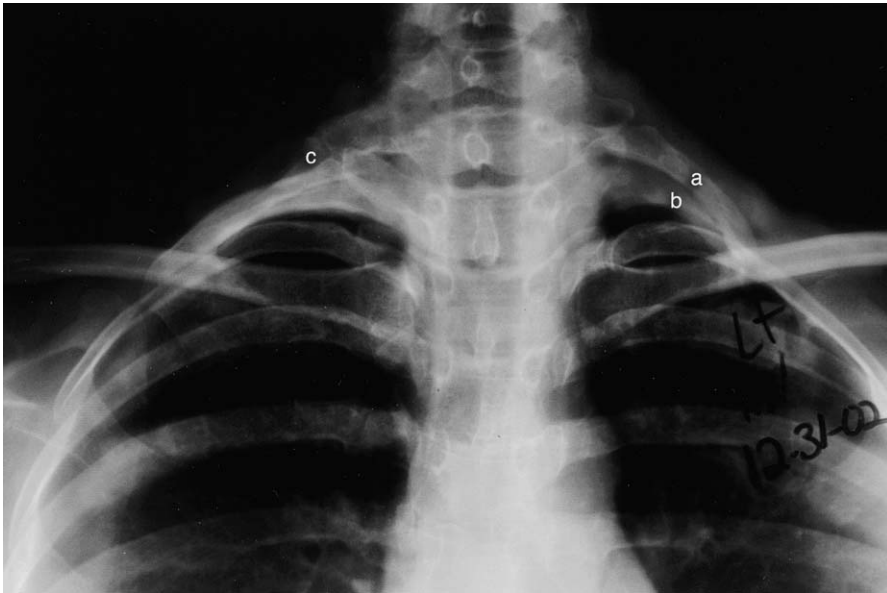


Fig. 4. This female radiology technician had a transaxillary resection of the left first rib leaving the cervical rib intact. Radiograph of the cervical spine shows the bilateral cervical ribs (the left one) (a) is 1.75-inch long with severe symptoms, and the absent (surgically removed) left first rib (b). The patient had very short-lasting and minimal improvement with full-blown recurrent symptoms on the left side. The right cervical rib is approximately 0.75-inch long (c) with minimal symptoms. (From The Christine M. Kleinert Institute for Hand and Microsurgery, Inc.; with permission.)

resection followed by transcervical anterior and medial scalenectomy).

In the first group, a total of 938 single procedure surgeries were performed as the primary surgery; the overall recurrence rate in this group was 30%–35%. In this group, 205 reoperations were performed on 186 patients for recurrent symptoms. The rate of secondary surgery for recurrence in this group was 22% (205 out of 938).

In the second group, a total of 532 combined procedure surgeries were performed as the primary surgery and the overall recurrence rate was approximately 5%–10%. On these patients only three reoperations were necessary. The rate of secondary surgery for recurrence in this group was much less than 1%.

A grading system similar to that used for the primary combined surgical results has been used to analyze patient improvement following secondary surgery for recurrent TOS. The author has reached the following conclusion: more than 80% of the patients reported improvement of their condition; 21% very good to excellent, 12% good, 46% better, and 21% fair to poor.

Sanders reported a similarity in the results of primary TOS surgery and reoperation for recurrence [1]. It is the author's impression that the

improvement rate is higher after the primary combined approach to TOS than the reoperation for recurrence. After 2 years, symptoms of recurrence occur less frequently. It takes a year or longer for the improvement or disappearance of all aches and pain after primary surgery. This also is true for secondary surgery.

### Summary

In the author's experience, the rate of recurrence is lower (5%–10%) when a combined procedure (transaxillary first rib resection followed by immediate transcervical anterior and middle scalenectomy) is performed as the primary operation. The author strongly believes this combined procedure accomplishes an excellent decompression of the thoracic outlet area and decreases the rate of recurrence and reoperation.

In addition, spontaneous recurrence most likely is caused when scar tissue gradually builds up in the surgical area. For this reason, as mentioned previously, the author instructs and encourages patients to start postoperative exercises the day after surgery and to continue these exercises for at least 6 months and preferably 1 year to improve

brachial plexus and subclavian vessel gliding and to minimize the harmful effects of scar tissue.

### References

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