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Functional Outcomes After Total Claviculectomy as a Salvage Procedure
A Series of Six Cases

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Background: Total claviculectomy has been used for the treatment of tumor, infection, nonunion, and vascular compromise. Given its limited indications, few reports on the outcome after claviculectomy exist. The purpose of the present study was to evaluate the function of the shoulder, with use of a modern scoring system, after total claviculectomy.

Methods: A retrospective review of the records of six patients who had undergone unilateral claviculectomy was performed after an average duration of follow-up of 5.7 years. The indication for surgery had been an infection at the site of a clavicular nonunion for three patients, nonunion with subclavian vein compression for two, and pain after a failed medial clavicular excision for one. The preoperative and postoperative evaluations included testing of the range of motion, strength, and stability as well as determination of the American Shoulder and Elbow Surgeons score on the basis of a functional questionnaire.

Results: Range of motion was improved slightly or unchanged following claviculectomy. The mean American Shoulder and Elbow Surgeons score improved from 18 (range, 5 to 35) preoperatively to 88 (range, 75 to 95) postoperatively. The mean pain level (with 0 indicating no pain and 10 indicating the worst pain) decreased from 9.5 preoperatively to 1.5 postoperatively. Postoperatively, strength testing showed improvement from grade 4 (of 5) to 5 in all planes tested except extension (in which it remained at grade 4). Patient satisfaction was high, with a mean of 9.0 on a 10-point scale. There were five complications, including one subclavian vein laceration requiring vascular repair, two deep infections, and two superficial infections.

Conclusions: Despite a high complication rate, the functional outcomes following claviculectomy were good in this group of six patients. Total claviculectomy may be a useful salvage procedure for clinical situations in which the restoration of normal clavicular osseous anatomy is impossible. Patients can expect acceptable pain relief and few or no deficits in activities of daily living.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

The function of the clavicle can be broadly divided into protective and structural aspects. While the protective aspect of clavicular function with respect to the great vessels and brachial plexus is widely accepted, the necessity of the clavicle for function in activities of daily living, including heavy overhead work, has been debated. The human clavicle theoretically facilitates positioning and the creation of a stable platform for the upper extremity in three dimensions. Its absence, however, does not always preclude full motion of the glenohumeral and scapulothoracic articulations.

Absolute indications for claviculectomy are rare. Relative indications have included tumor, vascular compression or injury, infection, symptomatic malunion and nonunion, and unipolar or bipolar dislocation. In the early 1990s, Rock-
wood and Wirth reported on patients with persistent symptoms following claviculectomy and recommended preserving the clavicle. Other studies have shown acceptable results following claviculectomy. However, objective data on patient outcomes are lacking in the literature. The purpose of the present study was to evaluate shoulder function, with use of a modern scoring system, in six patients who had undergone total claviculectomy.

**Materials and Methods**

From 1998 to 2001, six patients underwent unilateral total claviculectomy at our institution. The patients included four women and two men with an average age of thirty-seven years (range, twenty-five to forty-six years). The dominant arm was involved in four cases. The patients were followed for an average of 5.7 years (range, four to seven years). All patients underwent a careful preoperative evaluation, including testing and documentation of the range of motion, strength, and stability. They also filled out a functional questionnaire, which was used to calculate the American Shoulder and Elbow Surgeons (ASES) score. They also rated their pain on a scale of 0 to 10 (with 0 representing “unsatisfied” and 10 representing “completely satisfied”).

The indications for surgery included painful symptomatic nonunion after one or more attempts at open reduction and internal fixation in two patients, intractable infection in three, and regrowth after a partial medial claviculectomy (performed because of painful and unstable residual clavicular bone with neurovascular compression after failed sternoclavicular joint reconstruction followed by failed partial medial claviculectomy) in one. All patients had been operatively managed previously, with an average of three operative procedures (range, one to six procedures) having been performed prior to claviculectomy. Despite the number of previous procedures, all of the patients in this group had a functioning trapezius at the time of surgery. Five patients with nonunion had a history of tobacco use of more than one pack per day for an average of fourteen years.

Statistical analysis was performed with analysis of variance for quantitative values and with a chi-square test for qualitative values. The level of significance was set at p < 0.05.

**Surgical Technique**

The clavicle was exposed through a curvilinear extensile approach that followed the contour of the bone from the sternoclavicular joint to the acromioclavicular joint (Fig. 1). The musculofascial envelope and periosteum were incised in one layer along with the anterior aspects of the acromioclavicular and sternoclavicular ligaments. Careful blunt dissection was then carried out circumferentially, and the clavicle was gently disarticulated and elevated out of its bed (Fig. 2). A vascular surgeon was available on standby throughout the procedure.

After removal of the clavicle, the wound was irrigated thoroughly. The deltopectoral, trapezial, and sternocleidomastoid myofascial sleeves were meticulously repaired over a Jackson-Pratt drain with #2 Vicryl absorbable sutures (Ethicon, Somerville, New Jersey). A first-generation cephalosporin was administered preoperatively and was continued for twenty-four hours. The drain was removed at twenty-four to forty-eight hours.

The patients wore an arm sling for three to six weeks. Passive range of motion was allowed at three weeks, and active range of motion was started at six weeks. Theraband exercises in all planes were commenced at two months and progressed as tolerated. Shoulder shrugs and wall push-ups were encouraged. Formal physical therapy was not employed, and all patients were maintained on a home exercise program for a minimum of six months after surgery. This program involved thrice-weekly maintenance range-of-motion and resistance exercises for all shoulder girdle muscles.

**Results**

Demographic data from the six patients are shown in Table 1. Preoperatively, the mean active range of motion was 155° (range, 110° to 170°) of elevation, 60° (range, 35° to 80°) of external rotation, and 50° (range, 30° to 80°) of internal rotation. The mean ASES score was 18 (range, 5 to 35), and the mean pain level was 9.5 (with 0 representing no pain and 10 representing the worst pain). Strength ranged from 4 to 5 in all planes tested.

Postoperatively, the mean active range of motion was not significantly different from the preoperative range, with an average of 160° (range, 125° to 170°) of elevation, 65° (range, 45° to 80°) of external rotation, and 55° (range, 30° to 80°) of internal rotation. The mean ASES score was not significantly different from that of the preoperative range (mean, 18; range, 7 to 30), and the mean pain level was 2.7 (with 0 representing no pain and 10 representing the worst pain). Strength ranged from 5 to 6 in all planes tested.

**Postoperative Rehabilitation**

A home exercise program was started at six weeks. Passive and active range of motion exercises were started at two months, and exercises for all shoulder girdle muscles were started at three months. Formal physical therapy was not utilized, and all patients were maintained on a home exercise program for a minimum of six months following surgery. This program involved thrice-weekly maintenance range-of-motion and resistance exercises for all shoulder girdle muscles.
to 80°) of external rotation, and 70° (range, 50° to 80°) of internal rotation. The mean ASES score was 88 (range, 75 to 95) (p < 0.03). The mean pain score was 1.5. Compared with the normal side, strength was grade 5 in all planes except for extension (in which it remained at grade 4). The mean satisfaction score was 9.0 (with 0 representing “unsatisfied” and 10 representing “completely satisfied”). All patients stated that they would undergo this procedure again (Table II).

Radiographically, the involved scapula was an average of 1 cm more inferior and 1.6 cm more medial than the contralateral, normal scapula as determined on the basis of comparative measurements of the heights of the superomedial
corners and the distance between the coracoid and spinous processes, respectively.

One significant vascular injury occurred. During the dissection of the proximal part of the clavicle in a patient with known subclavian compression, a rent was created in the superior aspect of the subclavian vein. The vascular surgeon on call performed a primary repair, and no postoperative anticoagulation therapy was given. Twenty-nine months postoperatively, the patient was symptom-free and was very satisfied with the result. Four patients had an infection (prevalence, 67%). Of these, two had a deep infection that required aggressive treatment with surgical débridement and primary closure over drains as well as intravenous antibiotics and two had a superficial infection that was treated with oral antibiotic therapy alone. However, only one postoperative infection (which required surgical débridement) occurred among the three patients who had initially presented with chronic intractable infection in many of the patients, and the relatively superficial infection in the present series, total claviculectomy appears to have restored range of motion, created minimal strength deficits, and provided durable pain relief in this relatively young cohort of patients. However, this procedure is not without difficulties, as evidenced by the high rate of complications in the present study (with three of our six patients having a major complication). The close proximity to the major subclavian vessels puts these structures at risk during the surgical approach. Immediately available vascular surgery backup is recommended in case injury to the vessels occurs. Four infections (two deep and two superficial) occurred in our six patients. This finding was likely due to the large dead space created by the resection, the history of multiple operations and previous infection in many of the patients, and the relatively superficial nature of the clavicle. Rather than administering prophylactic antibiotics and considering the resection curative in patients with a previous history of infection, we recommend obtaining intraoperative culture specimens and administering postoperative antibiotics until the results of culture are returned, even in quiescent cases.

In all six of our patients, the trapezius was functional. We believe that the most important contraindication to claviculectomy is trapezius dysfunction, which can lead to severe functional loss and a drooping of the shoulder with thoracic outlet-type symptoms that may be exacerbated by removing the osseous strut of the clavicle.

**Discussion**

Gurd described the performance of complete claviculectomy as early as 1912. He later reported on several other clavicular resections, with excellent results. While midshaft clavicular osteotomy is a standard surgical technique for exposure of the underlying subclavian vessels and brachial plexus, total claviculectomy also has been used as an approach for vascular surgery and as a definitive treatment for tumors, infections, fractures, and nonunions of the clavicle. In 1986, Wood reviewed the literature as well as the results for five patients and concluded that the clavicle is an accessory to the osseous skeleton. That study was primarily a case report study. Subsequent reviews by Rockwood and Wirth, in a survey form, noted the anecdotal experience of the American Shoulder and Elbow Surgeons with this problem and concluded that claviculectomy was not a benign procedure. Their conclusion was that the clavicle should be preserved if possible.

Partial claviculectomies of both the medial and lateral halves of the clavicle have been reported to yield good, but not symptom-free, results. In those series, patients continued to complain of clicking and pain at the resected end of the clavicle. The cosmetic appearance of the resected end was also a source of relative dissatisfaction among these patients, causing a prominence in the anterior chest region. In the present series, total claviculectomy was performed for one patient after the failure of a previous partial medial claviculectomy. That patient had presented with a recurrence of neurovascular compression and pain due to regrowth of 5 cm of the clavicle at the site of a previous resection.

In the present series, total claviculectomy appears to have restored range of motion, created minimal strength deficits, and provided durable pain relief in this relatively young cohort of patients. However, this procedure is not without difficulties, as evidenced by the high rate of complications in the present study (with three of our six patients having a major complication). The close proximity to the major subclavian vessels puts these structures at risk during the surgical approach. Immediately available vascular surgery backup is recommended in case injury to the vessels occurs. Four infections (two deep and two superficial) occurred in our six patients. This finding was likely due to the large dead space created by the resection, the history of multiple operations and previous infection in many of the patients, and the relatively superficial nature of the clavicle. Rather than administering prophylactic antibiotics and considering the resection curative in patients with a previous history of infection, we recommend obtaining intraoperative culture specimens and administering postoperative antibiotics until the results of culture are returned, even in quiescent cases.

In all six of our patients, the trapezius was functional. We believe that the most important contraindication to claviculectomy is trapezius dysfunction, which can lead to severe functional loss and a drooping of the shoulder with thoracic outlet-type symptoms that may be exacerbated by removing the osseous strut of the clavicle.
An interesting finding of our review of the demographic data for this small cohort was that five of the six patients were smokers. While direct links between smoking and either fracture-healing or infection cannot be firmly established, it is interesting that these patients required the radical salvage operation of a total claviculectomy for the treatment of a previously unreconstructable problem. Additional study into the effects of smoking on nonoperatively and operatively treated clavicular fractures is currently under way.

It is hoped that the results of the present study will allow surgeons to inform patients of the potential outcome of this operation should it be deemed necessary. Despite the high rate of complications, including one complication that was potentially life-threatening, all patients in the present series were highly satisfied with the functional outcome at the time of the most recent follow-up and stated that they would undergo the procedure again. Our data are compatible with the majority of the reports on this subject. The outcomes demonstrated in our patient population seem to indicate that patients can expect acceptable pain relief and few deficits in activities of daily living. Claviculectomy should be kept in the armamentarium of orthopaedic and vascular surgeons for use in clinical situations in which the restoration of normal clavicular osseous anatomy is impossible.

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