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REVIEW ARTICLE

Is clavicular reconstruction imperative for total and subtotal claviclectomy? A systematic review

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Background: The effects of clavicular reconstruction on total and subtotal claviclectomy are controversial. The aim of this study is to disclose the impact of clavicular reconstruction on the efficacy of this rare surgical procedure.

Methods: This is a systematic review of multiple medical databases for level I through IV evidence.

Results: Eleven studies (level IV) with a mean follow-up duration of 53 months (range, 12-156 months) met the inclusion criteria. There were 70 subjects (70 shoulders) including 36 male patients (51%), and the average age at operation was 30 years (range, 2-77 years). The etiology included tumors in 34 subjects (49%) and other disorders in 36 (51%). Of the patients, 41 (59%) underwent total claviclectomy whereas 29 (41%) underwent subtotal clavicular excision. Clavicular reconstruction was performed in 14 subjects (20%), with bone allograft in 8, autograft in 1, and a bone cement prosthesis in 5. Objective measurement disclosed compromised strength and mobility in aclaviculate limbs; however, no studies investigating clavicular reconstruction used similar means of measurement. Functional assessment scales implied global limb function following the 2 procedures was similar (American Shoulder and Elbow Surgeons score, $P = .13$; Constant score, $P = .38$). Claviclectomy with and without reconstruction resulted in a similar incidence of complications ($P = .45$); however, isolated claviclectomy was related to fewer further surgical procedures ($P < .001$) and faster recovery ($P < .001$). The 2 procedures were associated with similar satisfaction rates ($P > .99$).

Conclusions: No evidence suggested clavicular reconstruction led to clinical outcomes superior to those of isolated claviclectomy. It is noteworthy that isolated excision of the clavicle was associated with a lower risk of further surgery and faster rehabilitation.

Level of evidence: Level IV; Systematic Review

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Keywords: Claviclectomy; cleidectomy; excision; reconstruction; clavicle; limb function

The clavicle is a doubly curved flat bone articulating with the acromion laterally and with the sternum medially. Its function can be divided into 5 aspects: (1) to meet the need for cosmesis, (2) to protect the subclavian structures, (3) to act

as the attachment of the musculature, (4) to act as a strut supporting the scapula, and (5) and to maintain the limb function.⁷ Total claviclectomy and subtotal claviclectomy are rare surgical procedures yet can be performed for a diversity of indications, including clavicular tumors, facilitation of surgical exposure, symptomatic nonunion, and refractory inflammatory disorders.^{6,7,11-16,22,26,27,32,33}

Several authors have suggested that clavicular reconstruction following total and subtotal claviclectomy (TSC) is

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imperative to prevent shoulder instability, an abnormal scapular motion, chronic shoulder joint damage, weakness, pain, an unsightly appearance, and injury to the subclavian structures.^{1,23} Previous literature has reported on various reconstructive protocols using autograft, allograft, and prostheses^{1,4,19,23,29} and revealed satisfactory functionality with restoration of shoulder appearance.^{1,4,19,23} However, clavicular reconstruction also has notable shortcomings: This procedure is technically demanding and requires slow rehabilitation with a considerable risk of complications.¹³⁻¹⁵ Complications after clavicular reconstruction include infection, prosthesis loosening, persistent pain, and symptomatic nonunion; if these events occur, patients usually receive additional surgical procedures and are likely to expect unsatisfactory outcomes.^{3,5,8,15} Li et al¹³ found that 5 of 6 subjects who underwent allograft reconstruction of the clavicle had wound problems, pain, nonunion, and loosening. After 6 additional surgical procedures, 2 allografts were eventually removed. Complications after clavicular reconstruction presented great challenges to the treatment.

Because of the favorable outcomes of isolated TSC reported in previous literature, the effects of clavicular reconstruction on TSC are debated. In 1916, Gurd⁷ first described favorable functionality after total claviclectomy for malignancy; the author believed the clavicle was only an accessory bone to shoulder function. Rossi et al²⁵ reported the outcomes of 4 patients who underwent partial and total claviclectomy; their findings implied the extent of clavicle excision was not related to limb function. Nagano et al²⁰ also observed satisfactory functional results of claviclectomy. However, a long-term study using objective measurements for functional assessment indicated the acclavicate limb function may deteriorate as compensatory ability is gradually lost.²⁶

Controversy about the impact of clavicular reconstruction on TSC is related to the following factors: (1) Total claviclectomy and subtotal claviclectomy are rare procedures, and therefore, the sample size is small; (2) there is considerable heterogeneity in patients' characteristics and etiology; and (3) most authors have applied subjective but not objective measurements for functional evaluation.^{9,30,33,34} Because of the rarity of TSC and obscurity regarding its outcomes, it is difficult to conclude whether clavicular reconstruction is imperative. Therefore, we conducted this systematic review (1) to analyze the outcomes of TSC with and without clavicular reconstruction and (2) to evaluate the effects of clavicular reconstruction on the efficacy of TSC.

Materials and methods

This systematic review of the available literature was performed by searching several medical databases: PubMed, Embase, Cochrane, Web of Science, and MEDLINE. The search was performed independently by 3 authors (Y.C., W.H., and B.W.) on March 28, 2017. This review was carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.¹⁸ The search dates were from the date of the establish-

ment of the databases to March 28, 2017. The terms searched included "claviclectomy," "clavicle" + "excision," "clavicle" + "resection," and "cleidectomy." The levels of the studies (level I to V) were confirmed by applying the criteria described in the "Levels of Evidence in Orthopaedic Journals."²¹ We reviewed articles with the potential for inclusion and drew conclusions regarding inclusion or exclusion through discussion.

Inclusion and exclusion criteria

The inclusion criteria were clinical studies with level I to IV evidence, English-language studies, studies investigating the clinical outcomes of TSC, and studies with a minimum of 12 months' follow-up. The exclusion criteria included the following: isolated case studies and level V studies; non-English-language studies; cadaveric and basic science studies; studies regarding imaging presentations; studies stating no functional outcomes; studies involving rotator cuff repair, shoulder arthrodesis, and resection of the shoulder girdle; studies investigating resection of less than half of the clavicle; and studies with less than 12 months' follow-up.

Results

Eleven studies (level IV evidence) met the inclusion criteria (Table I),^{6,11-16,22,26,31,32} Table II and Figure 1 show the search strategy and citation results. There were 70 patients (70 shoulders) including 36 male patients (51%), and the mean age at operation was 30 years (range, 2-77 years). The mean follow-up period was 53 months (range, 12-156 months, except for 1 death at 4 months). Of the subjects, 15 (21%) were children or adolescents, with an average age of 12 years (range, 2-16 years).

Etiology and surgical treatment

The etiology included tumors in 34 subjects (48%), subclavian structure exposure in 17 (24%), inflammation in 12 (17%), chronic traumatic pain in 3 (4%), symptomatic nonunion in 2 (3%), and pain after partial claviclectomy in 2 (3%). Of the patients, 41 (59%) underwent total claviclectomy whereas 29 (41%) underwent subtotal claviclectomy. Subperiosteal excision was performed in 9 cases (13%). In 56 subjects (80%), isolated claviclectomy was performed, whereas 14 (20%) underwent clavicular reconstruction using allograft (8 of 14 [57%]), autograft (1 of 14 [7%]), or a prosthesis (5 of 14 [35%]). A history of surgery was present in 15 patients (21%) (average, 2 procedures; range, 1-10 procedures).

Assessment of postoperative global limb function

Various scales were used to evaluate global limb function^{6,11-16,22,26,31,32}; as shown in Table III, the authors applied the American Shoulder and Elbow Surgeons score in 17 shoulders (24%)^{11,15,26} and the Constant-Murley score in 37 shoulders (53%).^{4,10} In addition, 11 shoulders (16%) were assessed with the Musculoskeletal Tumor Society score, whereas 6

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