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## Preliminary results of the use of Ilizarov fixation in clavicular non-union

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**Abstract** Although clavicular fractures are common, nonunion of clavicle is a rare complication. Clavicular nonunion that occurs due to insufficient stabilization is usually painful and necessitates operative treatment. Seven cases with oligotrophic clavicular nonunion that developed after a conservative process were treated with Ilizarov between January 2000 and December 2002. In all of them, the middle one-third of the clavicle was affected. Details of the cases regarding sex, age information, reason of fracture, previous treatment methods that were applied, nonunion area, nonunion, and duration of frame application were recorded. Two of the cases were female and five of them were male with age mean of 27.1 (19–32 years). Five of these cases had right clavicular injury and two of them had left clavicular injury. Mean nonunion duration was 18 months (range was 6–36 months). All nonunion were fixed and went through acute compression by means of Ilizarov's external fixators without grafting. The duration between the frame application and union was mean 2.7 months (range was 2.5–3.5 months). Mean follow-up period was 31 months (range was 22–48 months). Cases were evaluated in accordance with the Constant Scoring system. They were able to return to their normal daily activities in 10–15 days. All of them regained full shoulder movement and extension ability. Patients have also been evaluated by using Dash-Score. Union existed for all patients and none of them had any complaints of pain after treatment. Since circular external fixator allows acute compression, early shoulder movements, and re-

quires no such additional procedure as grafting, it is an alternative method which can be used in treating non-union of clavicle.

**Keywords** Fracture · Clavicle · External fixation · Nonunion · Ilizarov

### Introduction

Clavicular fractures are the most common types of fractures and one-third of the mid-clavicular region is the most vulnerable part due to biomechanical characteristics of the clavicle. Most of the clavicular fractures can be successfully treated conservatively. In some rare cases, primary or secondary surgical stabilization may be necessary [10, 14, 16, 18]. It was reported that the rate of incidence of clavicular nonunion was approximately 1% after conservative treatment, and 3.7–4.6% after surgery [14, 18]. Clavicular nonunion that occurs due to insufficient stabilization is usually painful and necessitates operative treatment [14, 16, 18]. Indications of nonunion that require surgical treatment can be listed as follows: pain, instability, deformity, limited shoulder ROM, and brachialgia [14]. Autogeneous grafting with intramedullary nail, or autogeneous grafting with plate osteosynthesis, and external fixation are surgical techniques recognized in the literature for the treatment of clavicular nonunion [1, 3, 7, 10, 12–14, 16, 20].

In this study, stabilization of clavicular nonunion by means of Ilizarov's technique and indications of this method are discussed. In addition, the technique of this treatment and conclusions were reported.

### Materials and methods

Seven cases with symptomatic clavicular nonunion were treated during the period between January 2000 and December 2002. Two of the patients were female and five of them were male with ages between 19 and 32

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**Fig. 1** Preoperative antero-posterior (AP) radiography of the 26-year-old case

(mean age was 27.1). Two of these cases underwent a conservative treatment with figure-eight sling at our department and five underwent the same at other centers. Reasons of clavicular fractures were that four cases had sports-related injuries and three had motor vehicle accidents. All fractures were closed. Five cases had impact on the right clavicle and two of them had on the left. Radiographic assessments were conducted for nonunions and all of them were oligotrophic. In all cases, the major surgical indications were pain at the nonunion area and ROM limitation secondary to the pain.

Details of the cases regarding sex, age information, reason of fracture, previous treatment methods that were applied, nonunion area, nonunion, and duration of frame application were recorded. The Ilizarov technique has been used for patients who have been classified as Types 2A2 and 2B1 according to the Robinson classification and for patients who have less than 1 cm shortness which occurred during surgery or resulted from a fracture [19]. Mean nonunion duration was 18 months (range was 6–36 months). For preoperative planning antero-posterior radiography showing two clavicles was used. Bone gap greater than 0.5 cm was not observed in any of the cases (Fig. 1).

All cases were given antibiotics during the period between preoperative and postoperative stages for 3 days (cefazolin sodium 2×1 g/day). They were allowed to take a shower at the second postoperative day provided they wore sterile drapes covering the shoulder over the frame. Information pertaining to these patients is shown in Table 1.

All patients underwent radiographic examination on 7th, 14th and 28th days of postoperation and later monthly radiographic examination. Patients have also been evaluated using Dash-Score.

### Surgical technique

The patient was positioned on the operation table in the supine position with a folded towel under the affected shoulder. The patient's arm was prepared to allow free movement. A 2- to 3-cm transverse incision was done at the clavicle's mid section. Nonunion area was revealed and fractured tips were freshened. Medullar channels were opened at both sides. First of all, a K-wire intramedullar to medial part was passed through the sternoclavicular joint. It was passed at least 1.5 cm lateral to the joint and taken out percutaneously. The same wire was inserted intramedullarly by means of a retrograde technique through the lateral part with clavicular alignment being maintained, and then taken out percutaneously at the distal clavicle.

Later, another K-wire was passed through the medial part and another one was passed through the lateral part transversely from 2 cm away from the nonunion area and with a right angle to intramedullary wire (Fig. 2). K-wires were fixed to Ilizarov frame with two rods to ensure stabilization, and acute compression was implemented through the fracture line (0.3–0.6 mm). The operation was ended after checking for bleeding. Mean operation time was determined as 50 min (45–60 min) (Fig. 3).

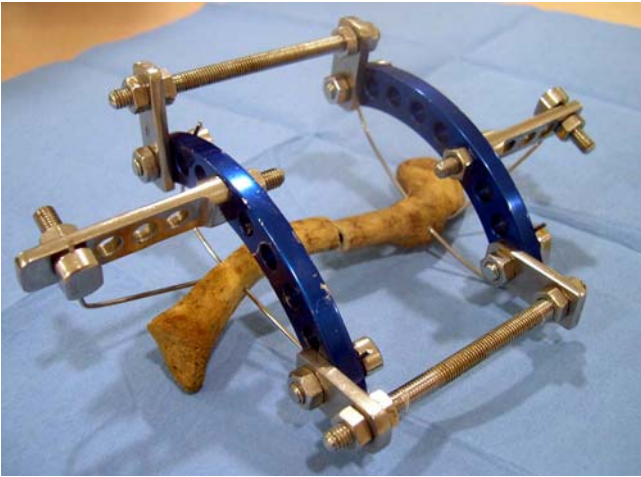
### Results

Results were evaluated in accordance with the Constant Scoring system. Union period was an average of 2.7 months (range was 2.5–3.5 months) for all cases and

**Table 1** Information pertaining to the patients who had clavicular nonunion

Case no.	Sex/age	Side	Mechanism of injury	Duration of nonunion (months)	Fixation time (months)	Preoperative constant scores	Postoperative constant scores
1	M/19	R	SI	6	2.5	42	92
2	M/26	R	SI	18	2.5	46	94
3	F/27	L	MVA	36	2.5	36	86
4	M/32	R	SI	18	3	48	94
5	F/27	L	MVA	17	3.5	42	92
6	M/29	R	MVA	20	2.5	48	94
7	M/30	R	SI	11	3	46	92

SI sports injury, MVA motor vehicle accident

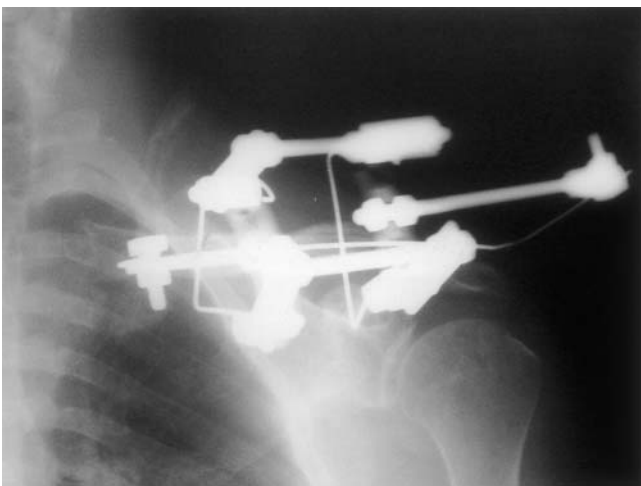


**Fig. 2** Design of Ilizarov frame

this was determined by radiographic examination. Once the union was determined, the frame was removed. The mean Dash-Score has been found  $15.6 \pm 8.8$  (4.1–30) postoperatively. While pain at the operation area gradually decreased for all cases starting from third day, no pain complaints remained on the seventh and tenth day.

All cases were asked to perform passive extremity movements on the first postoperative day and active shoulder movements on the third day (Fig. 4). Four patients returned to normal daily activities on 10th postoperative day and three of them on 15th postoperative day. They were not allowed to perform such activities as carrying heavy objects (over 5 kg) until 1.5 months. After removal of the frames, it was observed that all cases were able to perform full shoulder movements and regained shoulder power at full extension (Figs. 5, 6).

After the treatment, degree of shortness at the shoulder area was not greater than 1 cm for all patients.



**Fig. 3** Postoperative AP radiography of the 26-year-old case



**Fig. 4** Postoperative second day range of motion

Three cases had superficial pin track infection that was treated through oral antibiotics. No major complications such as wound infection, nerve dysfunction, or deep pin track infection were detected.

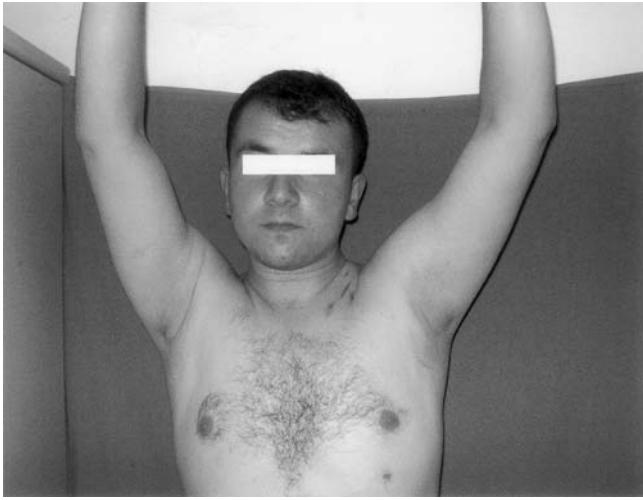
Mean follow-up period was 31 months (22–48 months). The results were scored as pain (15 points), daily activities (20 points), ROM (40 points), and power (25 points) in accordance with the Constant Scoring system [5]. Constant score was determined as 36–48 (44) at the preoperative stage and 86–94 (92) at postoperative stage.

## Discussion

Clavicular fractures are one of the most common types of injury. The rate of nonunion incidence after conservative treatment was reported as approximately 1%



**Fig. 5** Posttreatment AP radiography of 26-year-old case



**Fig. 6** Posttreatment range of motion

[14, 21]. Fractures and associated nonunions are usually observed at the middle one-third of the clavicle. Connolly and Dehne [4] stated that these types of nonunions can be observed as frequent as the other types of bone nonunions (like 3–5%). Among the factors triggering nonunion development are open fracture, re-fracture, associated multiple injuries, excess displacement, and insufficient stabilization. Clavicular nonunion is usually accompanied with pain. Pain, shoulder ROM limitation secondary to pain, shortness of the shoulder, or shoulder deformation require operative treatment.

Autogeneous grafting with intramedullary nail, or autogeneous grafting with plate osteosynthesis, and external fixation are surgical techniques for the treatment of clavicular nonunion. When the shoulder joint moves, clavicle is subject to compressive, bending and rotational stresses [10, 14, 22]. Although the plate is more resistant to rotational powers compared to intramedullary nail, it is thought that rotational stability has no critical role in the treatment of clavicular fractures [14, 22]. Therefore, intramedullary nails can be successfully combined with autogeneous grafting for treatment of both acute clavicular fractures and nonunion [18, 22].

If plate compression cannot be duly performed on clavicular nonunion in accordance with plating principles due to compressive and rotational stresses and whether or not there exists a gap in between regardless of grafting, the plate will be less stable when compared with intramedullary nailing [14]. Clinical implant insufficiency (breakage or loosening) is more common than intramedullary nailing [14, 18, 22]. In addition to all methods, Marti et al. [13] stated that AO plate–nail system could be used as an external fixation in clavicular nonunion treatment.

Boehm and colleagues stated that intramedullary nailing does not provide rigid fixation and is not able to control rotational powers, but they reported that negative impacts of rotational powers can be eliminated by limiting the flexibility of the upper extremity by 90° at

the early postoperative stage. In light of these opinions, they treated 21 patients with symptomatic nonunion at the middle of clavicle by means of intramedullary nailing, and reported 95% healing [2, 7].

For all surgical techniques, the shoulder must be immobilized for 2–6 weeks by an arm sling. It was reported that extremity lifting exercises up to 90° can be successfully performed after 3 or 4 weeks and according to some literature patients may even be able to perform full shoulder movements in 6–8 weeks after operation [1, 6, 8, 12, 22]. Ability to regain movement early is the biggest advantage of the Ilizarov technique.

Plating is not easy due to the complex three-dimensional morphology of the clavicle [7]. It is indicated in literature that especially 4.5 mm semi-tubular plate is not suitable for this kind of application [7]. Although it was reported that successful plate fixation could be achieved in some series, it is likely to have wider devascularization due to clavicular deperiostation [10, 14]. LC-DC plates may be more advantageous since they cause less damage to the bone [10, 14]. It was reported that there is a great degree of failure risk in some series where short semi-tubular plates are used [17].

In addition, plates must be removed when they are loose, they are not comfortable, or there are various skin problems and other cosmetic problems [3, 6, 9–12, 21]. The possibility to remove intramedullary nails by means of local anesthesia is an additional advantage of this method, whereas plates can be only removed under general anesthesia. The advantages of this method compared to other methods are that Ilizarov external fixator can be easily applied compared to plating, that no bone deperiostation occurs thereby no devascularization occurs during application, and that no additional surgery or general anesthesia will be necessary when removing the external fixator.

In all studies it was reported that grafting was performed in the treatment of clavicular nonunion [3, 7, 9, 14–16, 18]. In some studies, permanent numbness or hematoma at iliac crest was reported [7, 15, 16]. Since the tip of fractured bones can be intraoperatively freshened and it is possible to perform acute compression with Ilizarov circular external fixator system, no additional grafting is necessary; therefore, donor site morbidity does not occur.

Schuind et al. [20] used unilateral external fixation in their series to treat their patients. External fixation is a satisfactory technique for infectious and noninfectious nonunion as well as open fractures. Periost that is not stripped in external fixation is the most important factor contributing to early healing [14]. Pinning is very suitable due to the cortical structure of clavicle; thus good stabilization is achieved, bone healing is accelerated and early mobility is achieved with the shoulder and extremity. We achieved the same result with the Ilizarov external fixation system. Although Schuind et al. [20] reported some wound problem in cases where they used external fixation, we did not observe any deep wound infection. The reason for this may be that we used



1.8 mm diameter pins when performing the Ilizarov technique whereas others used wider pins in their studies. Also unlike the Ilizarov technique, unilaterally applied external fixator systems do not allow for sufficient compression at nonunion area due to three-dimensional morphology of the clavicle [14, 20].

## Conclusions

Intermedullary fixation or internal fixation with the LCDCP + autogenous grafting is usually used as the first treatment approach for the patient with 1 cm or more shortness in clavicular nonunion. However, in cases of oligotrophic, noncommitted fractures and when the shortness is less than 1 cm, the Ilizarov technique may be a specific treatment alternative with the main advantage of patients getting early mobilization and returning to their normal work and social lives. Other advantages are that it provides rigid compression through the nonunion line; it does not necessitate for bone grafting at donor site; and it is possible to remove the frame with a local anesthesia.

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