

SUBSPECIALTY PROCEDURES

MINI-INVASIVE INTRAMEDULLARY FIXATION
OF DISPLACED MIDSHAFT CLAVICLE
FRACTURES WITH AN ELASTIC TITANIUM NAIL

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Abstract

Background: The treatment of completely displaced midshaft clavicle fractures is still controversial, but surgical treatment provides a shorter recovery period and higher union rates than nonoperative treatment with a sling¹⁻⁵. Even though the literature does not clearly support surgery for these fractures, surgery is becoming more frequent⁶. Elastic stable intramedullary nailing (ESIN) with a titanium nail is a well-documented mini-invasive procedure with functional outcomes comparable with those of plate fixation after 1 year but a high rate of implant removal of up to 80%⁶⁻⁸. The ideal injury for ESIN is a fracture without comminution that is available for surgery within a couple of days. ESIN is also a good option for fractures with comminution, but a somewhat slower functional recovery during the first 6 months should be expected.

Description: The patient is placed in beach-chair position with the fluoroscope placed on the injured side or cranially in relation to the fracture. The surgeon pushes the skin gently with his/her index finger at the jugular fossa before incising it. This places the skin incision inferior to the implant. A 1 to 2-cm incision down to the bone is then placed about 1 to 2 cm lateral to the sternoclavicular joint. A unicortical entry hole is made at the medial end with a 2.5-mm drill bit and then widened and directed laterally with an awl. Two reduction forceps are placed percutaneously and used by the assistant to align the main fragments. The nail is passed with oscillating movements until it is secured into the lateral fragment. If it is not possible to obtain a closed reduction, an open reduction is performed. The nail is cut short down to the bone, and the myocutaneous layer and skin are closed with sutures. Five to 10 mL of bupivacaine is injected into the fracture area for postoperative pain management. The arm is placed in a simple sling for comfort. A non-weight-bearing active range of motion of <90° is encouraged.

Alternatives: Closed completely displaced midshaft clavicle fractures can be treated operatively or nonoperatively with a sling. Superior plate fixation is well documented, but use of anterior or several

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mini-fragment plates is also an option. There are several intramedullary implant techniques, but most require an open reduction.

Rationale: Most intramedullary implant methods are open procedures, whereas closed reduction and internal fixation is possible with ESIN. This ensures preservation of the fracture hematoma and no periosteal stripping, in contrast with the open intramedullary techniques. The nail enters the fracture medially, which decreases the chance of perioperative pulmonary or neurovascular injury. The procedure is less time-consuming than plate fixation, the result is cosmetically superior, and the functional outcomes after 1 year are equal. When ESIN is used for fractures without intermediary fragments, the functional recovery time is equal to that after plate fixation, although it is longer when used for fractures with intermediary fragments⁸.

Introductory Statement

Elastic stable intramedullary nailing (ESIN) of midshaft clavicle fractures is a well-documented mini-invasive procedure with predictably excellent functional outcomes.

Indications & Contraindications

Indications

- Open fractures of the middle third of the clavicle.
- Completely displaced midshaft clavicle fractures.

Contraindications

- Active infectious process close to the site for the procedure.
- Previous fracture of the clavicle that might obliterate the medullary canal.
- We prefer plate fixation for clavicle fractures with an associated neurovascular injury that needs to be addressed, as plate fixation requires less manipulation of the clavicle.

Step-by-Step Description of Procedure (Video 1)

Video 1 The procedure step by step.

Step 1: Preoperative Planning

Obtain 1 caudal and 1 cranial standing radiograph with sufficient spread between the projections to see the degree of fracture displacement and to evaluate intermediary fragments.

- Obtain standard 15° caudal and 15° cranial radiographs to evaluate the fracture displacement and intermediary fragments.
- Try to get an impression of the medullary canal diameter and the suitability of the diameter of the selected nail by holding the nail in front of the clavicle and viewing on fluoroscopy. Usually, a 2.5-mm nail will suffice, although a 3.0-mm nail will be needed in larger individuals.
- The presence of intermediary fragments will make a closed procedure more difficult.
- Previous fractures of the clavicle may obliterate the medullary canal and complicate use of ESIN.

Step 2: Patient Positioning

We prefer the beach-chair position, with the C-arm placed cranially or laterally at the injured side.

- Use general anesthesia.
- Position the patient in the beach-chair position on a radiolucent table (Fig. 1).
- The ipsilateral arm should be mobile.
- The procedure requires 1 surgeon to insert the nail from the uninjured side and another to perform the reduction from the injured side.
- Place the C-arm cranially or laterally at the injured side. A cranial C-arm position provides an easier working environment for the surgeons, whereas a lateral position provides better access for the anesthesiologist.



Fig. 1

Fig. 1 The patient is placed in the beach-chair position with the injured arm draped free.

Step 3: Surgical Approach

Perform a medial incision just lateral to the sternoclavicular joint and down to the bone.

- Enter the medullary canal from the medial side.
- Push the skin down cranial to the clavicle with your non-dominant index finger to keep the skin incision away from the implant (Fig. 2).
- While holding the skin away, place a 1 to 2-cm skin incision 1 to 2 cm lateral to the sternoclavicular joint.
- Incise directly to the bone.

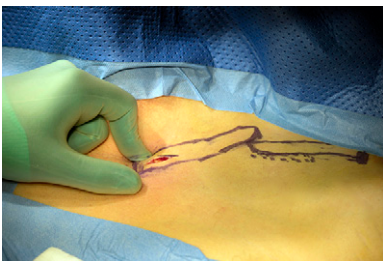


Fig. 2

Fig. 2 Push down the skin cranial to the clavicle so that the skin incision will be placed away from the implant.

Step 4: Nail Entry

Open the medullary canal unicortically and insert the nail.

- Place your index finger and thumb on either side of the clavicle. This ensures that your entry point will be centralized on the clavicle (Fig. 3).
- Open the medullary canal with a 2.5-mm drill bit passed through a serrated drill sleeve to minimize the chance of the bit slipping to either side of the bone.
- Open unicortically, and insert an awl to widen the opening, first perpendicularly and then directed along the axis of the clavicle. Confirm the position with fluoroscopy. The oblique opening facilitates nail entry and should be slightly larger than the diameter of the selected nail (Figs. 4-A, 4-B, and 4-C).
- Attach the inserter to the nail and use the curved nail tip to slide on the cortex (Fig. 5). Some manufacturers provide a laser mark on the end of the nail that is aligned with the direction of the bent nail tip.
- In some patients, the medullary canal is very narrow. In such cases, it is possible to straighten the bent tip to facilitate entry.
- Do not use a nail with a diameter smaller than 2.5 mm as a 2.0-mm nail construct is too weak and associated with implant failure⁸.
- If a 2.5-mm nail with a straightened tip cannot be passed, you can either open the fracture site and widen the medullary canal medially and laterally with a 2.5-mm drill bit or convert to plate fixation.

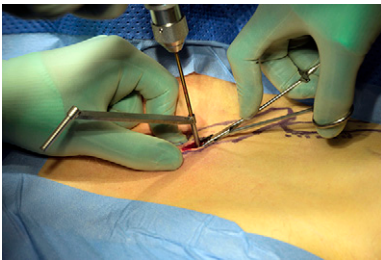


Fig. 3



Fig. 4-A

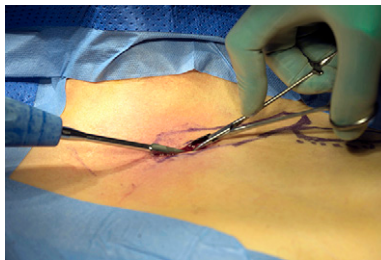


Fig. 4-B

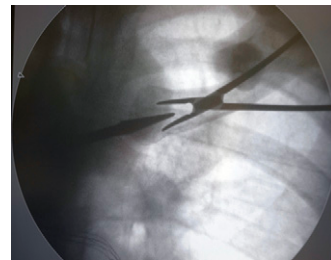


Fig. 4-C

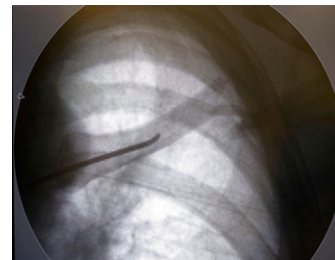


Fig. 5

Fig. 3 Place your index finger and thumb on either side of the clavicle to centralize your entry point.

Fig. 4-A Slide the awl into the entry hole and verify the position with the fluoroscope.

Figs. 4-B and 4-C With oscillating movements, turn the awl in the direction of the clavicle.

Fig. 5 Use the curvature of the nail to slide on the cortex.

Step 5: Reduction of the Fracture

Place 2 percutaneous reduction forceps to reduce the fracture.

- Advance the nail to the fracture site with oscillating movements or with hammer blows to the impactor.
- The nail is most flexible between the inserter and the bone. Keep this distance to a minimum but make sure not to cause a skin abrasion. A 2.5-mm drill sleeve may be used to increase the stiffness and ease the nail advancement (Fig. 6).
- Make stab incisions and attach 1 pointed reduction clamp on the medial side of the fracture and 1 on the lateral side (Fig. 7).
- The assistant lifts the lateral fragment up to align it with the medial fragment (Figs. 8-A and 8-B). If the patient is heavy, it might help to pull on the arm in the axial direction.
- Do not push the medial fragment down as this may align the exit of the nail from the medial fragment with the subclavian artery or vein.
- Use the image intensifier in 2 planes to visualize and confirm the reduction.



Fig. 6



Fig. 7

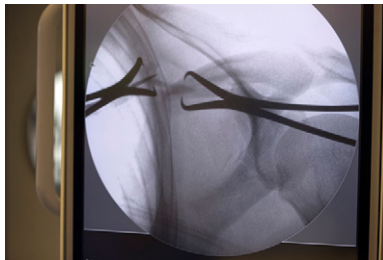


Fig. 8-A

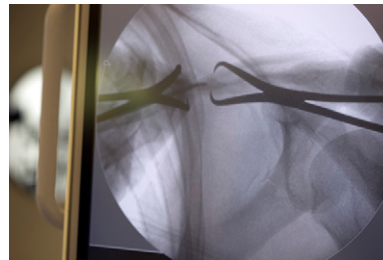


Fig. 8-B

Fig. 6 A drill sleeve may be used to increase the nail stiffness.

Fig. 7 Percutaneous placement of reduction clamps.

Figs. 8-A and 8-B The lateral fragment is aligned with the medial fragment, and the position is verified with fluoroscopy.

- Advance the nail to the lateral fragment using the bent tip of the nail to aid in this maneuver (Figs. 9-A through 9-D).

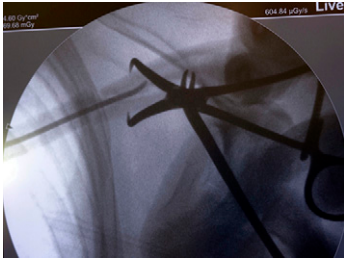


Fig. 9-A

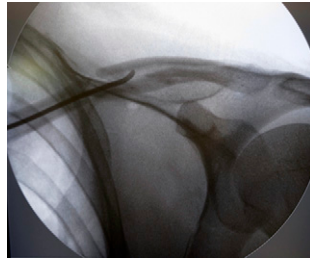


Fig. 9-B

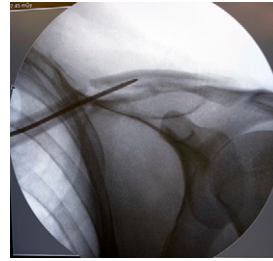


Fig. 9-C



Fig. 9-D

Figs. 9-A through 9-D Use the curvature of the nail tip to facilitate entry into the lateral fragment and align it with the flattened lateral end of the clavicle.

Step 6: If Closed Reduction Fails

If closed reduction is not possible, an open approach to the fracture facilitates nail entry into the lateral fragment.

- If a closed procedure is not possible, an open procedure can be performed.
- If the medullary canal is very narrow, consider the possibility that you will have to convert to plate fixation and perform a transverse 3 to 4-cm incision. If the canal width does not seem to be an issue, it is possible to make a vertical incision with the Langer lines, which might be cosmetically more pleasing.

Step 7: Securing Lateral Anchoring

Advance the nail laterally, but be aware of the flat anatomy and curvature of the lateral end of the clavicle.

- After advancement of the nail to the lateral side, be aware of the flattened shape and the anterior curvature of the lateral end of the clavicle. Align the tip of the nail with the flat medullary canal, with the tip positioned anteriorly as you reach the lateral curvature (Fig. 10). Failure to do so might lead to lateral cutout and an insufficient lateral anchorage. The tip will penetrate the cortex if the tip is turned too much. Using hammer blows is a good option.
- If the nail cuts out laterally, reposition it and advance it past the perforation.

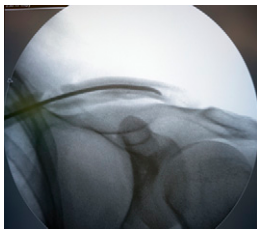


Fig. 10

Fig. 10 Advance the nail to ensure lateral anchoring.

Step 8: Cutting the Nail

Leave the nail short to prevent future medial skin tenting.

- Cut the nail down to the bone with a wire cutter.
- One of the major complaints after ESIN is painful medial prominence of the nail at the entry site. There needs to be as little nail prominence as possible in order to reduce the chance that the nail will have to be removed.
- After the nail is cut medially, advance it further with an impactor to reduce prominence (Fig. 11).



Fig. 11

Fig. 11 After the nail is cut, use an impactor to advance it further.

Step 9: Wound Closure

Close the wound in 2 layers and place the arm in a simple sling.

- Close the myofascial layer with absorbable sutures, close the skin with simple sutures, and reinforce with adhesive skin strips if the wound is under tension.
- The stab incisions from the reduction clamps can be closed with adhesive skin strips only.
- Administer 5 to 10 mL of bupivacaine in the fracture site for postoperative pain relief.
- Place the arm in a simple sling.

Step 10: Rehabilitation

A simple sling is worn for initial comfort, and active non-weight-bearing movements are encouraged.

- The patient wears a simple sling for 1 to 2 weeks for comfort but is encouraged to take the arm out and move the shoulder and elbow.
- The patient is encouraged to engage in active non-weight-bearing movements with $<90^\circ$ of abduction until callus formation.
- Follow up at 6 weeks with radiographs. If callus formation is present, full weight-bearing is allowed.

Results

We conducted a prospective randomized controlled trial comparing superior plate fixation with ESIN for completely displaced midshaft clavicle fractures in 123 patients treated at Akershus University Hospital, Norway⁷. The main finding in this study was that both methods allowed the patients to return to their preinjury functional levels within 1 year, but the recovery period after plate fixation was shorter than that after use of the ESIN for patients who had a comminuted fracture. There was no difference between the methods at any time point for patients who had a fracture without intermediary fragments. The duration of surgery was shorter for ESIN (mean, 53.4 minutes; range, 22 to 120 minutes) than for plate fixation (mean, 69.7 minutes; range, 35 to 106 minutes; $p < 0.001$). The patients treated with ESIN rated their satisfaction with the cosmetic appearance more highly on a 10-point visual analog scale (VAS) (mean, 8.6; range, 3.5 to 10) than the patients treated with plate fixation (mean, 7.7; range, 0 to 10; $p = 0.03$).

ESIN was associated with a lower infection rate and implant failure rate (when a nail of ≥ 2.5 mm was used) compared with plate fixation, indicating that ESIN was the preferred method for midshaft fractures with no comminution. However, plate fixation provided faster rehabilitation when there were intermediary fragments, and most patients (73%) in this series did have intermediary fragments. Subgroup analysis showed that ESIN with closed reduction had a better functional result than ESIN with open reduction at all time points for all scores except the Constant score at 1 year. Multivariate logistic regression for hierarchical data revealed an increase in the odds of an open procedure if surgery was delayed and if the fracture was comminuted.

Pitfalls & Challenges

- Do not open the cortex of the clavicle with an awl. It may slide off the side and cause vascular or pulmonary injury.
- The beveled impactor has a slot that may be used to bend the curved tip of the nail (Fig. 12).
- Do not place the entry point too medially. This may cause irritation of the sternoclavicular joint.
- Protrusion of the nail against the skin causes localized pain and may warrant implant removal. Try to leave the cut nail end as close to the cortex as possible.
- Adding an end-cap does not reduce implant irritation⁹.
- Bending of the medial nail end to facilitate removal will usually cause a painful protrusion.
- Segmental and severely comminuted fractures may experience a telescoping effect resulting in some shortening of the clavicle but also medial protrusion.



Fig. 12

Fig. 12 Local anesthesia may be injected for postoperative pain management.

- If the medial end is protruding and the fracture has not yet healed, it is easy to cut the nail short with use of local anesthesia in the outpatient clinic.
- A protruding medial end may result in wound dehiscence around the nail. We have treated this successfully, by cutting the nail shorter with use of local anesthesia and a short course of oral antibiotics.
- If the medial end of the nail protrudes and the fracture has healed, the nail can be successfully removed with local anesthesia in the outpatient clinic in about 50% of cases; general anesthesia will need to be used in the other 50%.
- Intramedullary nailing should be performed as early as possible after the injury, as this increases the odds of being able to perform a closed procedure, which seemed to be advantageous in our study⁷.

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