Clavicular fractures are common injuries, accounting for 2%–5% of all fractures and occurring with an incidence of 64 per 100,000/year.1-4 Approximately 70%–80% of clavicle fractures involve the midshaft (middle third), with males accounting for about 70% of these fractures.1-4 Given that the average age of a patient sustaining a midshaft clavicle fracture is 33 years, any functional deficit associated with the injury may have a substantial economic impact.1 Additionally, nonunions and malunions of the clavicle can lead to substantial long-term sequelae, including persistent pain, weakness, and loss of range of motion.2

Operative vs Nonoperative Care
Traditionally, midshaft clavicle fractures have been treated nonoperatively with either a sling or figure-of-eight harness.1 This treatment strategy was based on early studies in the medical literature suggesting that the nonunion rate for clavicle fractures was under 1% and that very few patients had long-term functional deficits related to the fracture.1,3 However, more recent studies have shown increased rates of nonunion, symptomatic malunion, and unsatisfactory patient outcomes with nonoperative management.3,5-7 For example, a number of studies have reported nonunion rates as high as 13%–15% and a 20%–25% decrease in shoulder and arm strength at 5-year follow-up for patients treated nonoperatively.1,3 A 2005 meta-analysis by Zlowodzki and colleagues on displaced midshaft clavicle fractures showed a nonunion rate of 15.1% after nonoperative care vs a nonunion rate of 2.2% after treatment with operative plate fixation, a relative risk reduction of 86% (95% confidence interval, 71%–93%; P<0.001).3,5
Similarly, a 2007 prospective, randomized, controlled trial by the Canadian Orthopaedic Trauma Society comparing plate and screw fixation to nonoperative management of displaced midshaft clavicle fractures found that patients in the operative fixation arm of the study had a decreased time to union of 16 weeks (vs 28 weeks in the nonoperative arm) and statistically significant improvements in the Constant Shoulder Score and Disabilities of the Arm, Shoulder, and Hand (DASH) Score. The study also showed a lower rate of malunion and nonunion in the operative fixation arm compared to the nonoperative treatment group at 1-year follow-up. Complications with operative fixation were mostly hardware-related (ie, local irritation and/or prominence of the hardware, wound infection, or mechanical failure).

Surgical Options: Intramedullary, K-Wire, or Plate Fixation
The findings from the studies cited on page 1 have prompted physicians to consider surgical options for treating these injuries. Surgical options for treatment of displaced midshaft clavicular fractures include elastic intramedullary nails, K-wires, or plate fixation. A potential disadvantage of K-wire fixation is that migration of K-wires can occur. Plate fixation, on the other hand, has proven to be reliable and reproducible, leading to union rates ranging from 95% to 100% with a low rate of associated complications. Plate fixation is the procedure of choice for the treatment of open clavicle fractures, severely displaced fractures, and nonunions.

Plate Location: Anteroinferior or Superior
Options for plate location are either the anteroinferior or superior surface of the clavicle. Potential advantages of anteroinferior plating include allowance for the surgeon to direct instrumentation away from the infraclavicular neurovascular structures, longer screw purchase, and less hardware prominence, minimizing the need for implant removal. Potential advantages of applying the plate superiorly include avoidance of detachment of muscles, higher axial compression, higher fracture rigidity, and retained stiffness. Anteroinferior placement has recently gained popularity, partly due to decreased implant prominence and partly due to improved clinical outcomes. In the systematic review of 2,144 clavicle fractures, Zlowodzki and colleagues reported that plating in the anteroinferior position caused less postoperative symptoms compared with plating in superior position. Similarly, a 2013 study by Formaini and colleagues comparing anteroinferior plating to superior plating reported that anteroinferior plating was associated with fewer implant removal surgeries (9% vs 19%).

Locked or Non-Locked Plate Design
Clavicle plate design options include locked and nonlocked plates. Recent studies of clavicle fracture plating designs show that locked plates provide optimized stability and a more rigid construct than conventional plates. For example, a biomechanical study by Celestre and colleagues evaluating the properties of locking plates versus nonlocking plates in a midshaft clavicle fracture model found that locked plates demonstrated significantly greater bending stiffness than nonlocking plates. A 2012 retrospective case control study of 54 patients by Lai and colleagues comparing locked plates with dynamic compression plates in patients with midshaft clavicle fractures found both types of plates achieved satisfactory operative outcomes with no statistical differences for operative time, complication rate, hospital stay, or union rate. Of the 54 patients, plates were removed from 20 patients, 12 from dynamic compression group (66.7%) and 8 from the locked plate group (28.6%). This difference was statistically significant.
Overview of DePuy Synthes Trauma Clavicle Plates

For fractures, a comprehensive portfolio of six clavicle plate designs is included within the Modular Clavicle Plate System:

- 2.7 mm/3.5 mm VA LCP Lateral Anterior Clavicle Plate
- 3.5 mm LCP® Superior Clavicle Plate
- 3.5 mm LCP Superior Clavicle Plate with lateral extension
- 3.5 mm LCP Superior Anterior Clavicle Plate
- 3.5 mm LCP Superior Anterior Clavicle Plate with lateral extension
- 3.5 mm LCP Medial Anterior Clavicle Plate

Modular Clavicle Plate System Features
The plates are housed in a modular graphic case designed specifically to accommodate all three plate families (anterior, superior, and superior anterior clavicle plates), compatible screws, and the specific clavicle instruments. The modular design and common instrumentation for all plates may minimize hospital inventory.

LCP Clavicle Hook Plate Overview
DePuy Synthes Trauma also offers a 3.5 mm LCP Clavicle Hook Plate, designed to treat lateral clavicle fractures and acromioclavicular joint injuries. The plate is anatomically precontoured to facilitate optimal implant placement and includes a rounded shaft profile designed to minimize soft tissue irritation between the plate and the surrounding soft tissue. The undercuts in the shaft are designed to reduce impairment of the blood supply and a 12° bend in the shaft aids with implant placement.

The 3.5 mm LCP Clavicle Plate system is indicated for fixation of fractures, malunions, nonunions, and osteotomies of the clavicle in adults, and in both adolescents (12-18 years) and transitional adolescents (18-21 years), in which the clavicular growth plates have fused or in which the growth plates will not be crossed by the plate system.\(^\text{14}\) Unlike those of DePuy Synthes Companies of Johnson & Johnson, the majority of competitive clavicle plating systems do not include adolescent indications.
Biomechanical Testing and Design Rationale

Higher Resistance to Bending
A recent DePuy Synthes Companies of Johnson & Johnson biomechanical study examining plate strength of 3.5 mm Superior LCP Clavicle Plates vs 3.5 mm LCP Reconstruction Plates found that under a constant static load, the clavicle plate did not yield until approximately 142 N where the recon plate yielded around 104 N. The results of this study indicate that the clavicle plate has approximately 40% higher strength compared to the recon plate.  

![Figure 1. Plate strength as measured by mean peak load (N)](image)

Rationale for Clavicle Plate Curvature: Anatomic Fit
Plates featuring a precontoured design may provide for a better anatomical fit. DePuy Synthes Companies of Johnson & Johnson analysis of 48 individual clavicle bone specimens from the University of Tennessee William Bass Bone Collection was undertaken to determine a preferable clavicle plate curvature design. The specimens were selected at random, scanned using a 3D-laser scanner system, and analyzed in Pro-E, applying best fit Anterior (AC1 and AC2) and Superior (SC1 and SC2) curves to the bone. In general, it is easier to bend a plate than it is to remove a bend in a plate. As a result, the contour of the anterior plate design is approximately one standard deviation above the AC1 and AC2 averages; therefore, the plates are designed with slightly less contour than the anatomic specimens.

Note: Bench tests are not necessarily indicative of clinical results.
Design Elements and Clinical Benefits of the DePuy Synthes Trauma 2.7 mm/3.5 mm Variable Angle LCP Anterior Clavicle Plate

The DePuy Synthes Trauma 2.7 mm/3.5 mm VA LCP Anterior Clavicle Plate features a number of design elements (Figures 3-4) that may translate into procedural and clinical benefits for the surgeon and patient.

The variable angle locking holes feature four points of threaded locking between the plate and the variable angle locking screw, providing increased stability and forming a fixed-angle construct. This type of fixed-angle construct provides advantages when used in osteopenic bone or for multifragment fractures. Variable angle locking holes improve screw targeting for various fracture patterns (Figure 4).

The head of the variable angle locking screw is rounded in order to facilitate the various angles within the locking holes. Variable angle screws can be angled anywhere within a 30° cone around the central axis of the plate hole.
Anatomic Design with Low-Profile Fixation

All DePuy Synthes Trauma clavicle plates feature a precontoured design for anatomical fit. The screwhead recess is designed to minimize screw prominence, creating a low-profile construct (Figure 5).

The rounded plate profile and screwheads sit flush in the plate to minimize the risk for soft tissue irritation. Reconstruction plate segments allow additional contouring of plates to fit patient anatomy while the tapered plate tip facilitates percutaneous insertion and minimizes soft tissue irritation.

Additionally, DePuy Synthes Trauma clavicle plates are designed with Combi holes that allow fixation with locking screws for angular stability and cortex screws for compression.

Enables Preservation of Blood Supply

DePuy Synthes Trauma clavicle plates have a limited-contact shaft profile on the underside of the plate. This feature may limit plate-to-bone contact and reduce impairment of the blood supply.
Early, Active Mobilization

The ability to return to work and sports activities are questions often asked by patients when considering operative and nonoperative treatment options. A 2013 retrospective case control study by Althausen and colleagues examined the impact on return to work of operative vs nonoperative treatment of displaced clavicle fractures using clinical and financial data obtained from a hospital database of orthopaedic fractures and patient questionnaires.¹⁷ All patients in the open reduction internal fixation arm underwent superior plate fixation with precontoured clavicular locking plates. Return to work data were self-reported and indicated that operative patients missed a mean of 8.38 days of work whereas nonoperatively managed patients missed 35.15 days (Table 1).¹⁷

Operatively managed patients were able to return to work sooner, returning to light duty at 8.38 days vs 35.15 days in the nonoperative group and to full duty at 35.92 days vs 61.15 days in the nonoperative group.¹⁷ Operatively managed patients also required less caregiver assistance (3 days vs 6.95 days) for care at home.¹⁷

Van Olden and colleagues’ 2013 study of patients receiving the VA LCP Anterior Clavicle Plate for the treatment of clavicle fractures also reported shortened return to work timelines.¹⁸ Of the 42 patients treated in this study, results indicated that patients averaged a return to work and sports activities 2.1 weeks (15 days) after injury.¹⁸ Additionally, the clinical evaluation of these patients reported a mean Constant Score of 94 (Range 53-100) at 6 weeks and 97 (Range 81-100) at 24 weeks.¹⁸ The authors conclude that anterior-inferior plating with the DePuy Synthes VA LCP Clavicle Plate appears to be a safe and effective method of treating clavicle fractures when operative treatment is necessary and that the variable angle screws on the lateral side enable perfect biocortical positioning and mechanical stability.¹⁸

<table>
<thead>
<tr>
<th></th>
<th>Operative Group (n=66)</th>
<th>Nonoperative Group (n=83)</th>
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<td>35.15</td>
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<td>Family member days of work missed</td>
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<td>Initial light duty</td>
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<tr>
<td>When released to full duty</td>
<td>35.92</td>
<td>61.15</td>
<td>0.0252</td>
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</tbody>
</table>
DePuy Synthes Trauma: A Clinical Heritage in Plate Technology

Through the years, plate and screw technology has evolved to continually improve surgical outcomes. DePuy Synthes Trauma has been an innovator and market leader in plating technology for over 50 years. Fifteen years ago, DePuy Synthes Trauma introduced Locking Compression Plate (LCP) technology. Locking compression plates represented an important milestone in patient care, merging locking screw technology with conventional plating techniques. DePuy Synthes Trauma offers a comprehensive range of plate and screw systems to address a large variety of fracture patterns in the clavicle, humerus, ulna, radius, hand, pelvis, femur, tibia, fibula, and foot. Since LCP technology was introduced, DePuy Synthes Trauma locking plates have delivered successful clinical outcomes for patients all over the world.

Conclusion

DePuy Synthes Trauma clavicle plates have been designed with several unique features that may translate into clinical and procedural benefits for both the patient and surgeon. These plate design features include precontoured plates for anatomical shape, rounded plate profile, limited-contact shaft profile, Combi holes, and a tapered plate tip. DePuy Synthes Trauma 2.7 mm/3.5 mm VA LCP Clavicle Plate also features variable angle locking. DePuy Synthes Trauma’s comprehensive clavicle plate portfolio includes 38 different plate options, which potentially allow for an improved patient fit.

The clinical and procedural benefits include stable fixation, anatomic reduction, preservation of blood supply, and early, active mobilization. These benefits are the same four principles formulated by the Arbeitsgemeinschaft für Osteosynthesefragen (AO) in 1958 which have since become the standard for internal fixation. Recent clinical studies of operative vs nonoperative treatment for displaced midshaft clavicle fractures have demonstrated that plate fixation reduces the rate of nonunions, improves functional outcomes, and has a low rate of complications. Overall, clinical studies support primary plate fixation for displaced clavicle fractures.
References


DePuy Synthes Trauma offers expert sales consultant service and support, including state-of-the-art education and training.

CAUTION: Federal Law Restricts These Devices To Sale By Or On The Order Of A Physician.

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