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Original article

Conical coupling angular stable plate fixation: a retrospective study

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Summary

Backgrounds. Conical coupling represents an alternative to screw coupling on angular stable plate fixation. Aims of the present study was to evaluate clinical effectiveness and ease of plate removal of conical coupling locking plates into different scenario regarding quality of bone, type of fracture and operative technique. *Methods.* From May 2013 to December 2017, 198 patients with 206 fractures underwent open reduction and internal fixation with conical locking plate. In most cases fixation involved wrist (38%) and clavicle (24%) fractures but a varied type of fractures and bone were included in the study. *Results.* Ten complications related to plate fixation were observed (5,1%). Two case of intra-articular positioning of screws of wrist plate. One case of loss of reduction and breakage of wrist plate due to an inappropriate proximal fracture fixation. Five cases of complications involved clavicle fixation: three cases of non-union, one case of peri-implant fracture, one screw loosening. One non-union of distal tibial fracture, one non-union in olecranon fracture were finally observed. Thirty-four patients that have symptoms that could be traceable to the implants in-situ underwent plate removal. No complications were observed during surgical plates removal. Conical coupling angular stability plate represents an actractive alternative to threaded angular stability plate. Bush titanium insert, eliminating the problems of cold welding and cross-threading, simplifies surgical screws and plate removal

Key words stable plate fixation, conical coupling, locked plate

Introduction

Internal fixation with plates is a proven and commonly used technique in articular and periarticular bone fractures treatment. Locked plate technology was introduced in orthopaedics practice to overcome the limitations associated with conventional plating methods, primarily for improving fixation in osteopenic bone and in comminuted fractures. The lack of intimate contact between plate and bone has led locking plates to be called "internal fixators" taking advantage of the concepts of external fixation (1,2). In comparison to external fixators, internal fixators offer more stability by being closer to the bone. Preserving the periosteal blood supply theoretically prevents stress shielding, reduces infection risks, and promotes fracture consolidation. Therefore, locked plate technology was developed as a consequence of improved understanding of the roles of tissue vascularity and gap strain in fracture healing. A locked plate converts an axial load shear force into a compressive stress at the screw bone interface. The strength of fixation is equal to the sum of the entire screw bone interface of all the screws as opposed to a single screw as in unlocked screws (1,2).

The LCP system has widely been used and today represents the "gold standard" in plate osteosynthesis. In particular the LCP screw-hole interface with threaded surfaces is the strong point of these systems. However, the LCP mechanism of angular stability has some issue, like the cold welding and cross-threading effect. These problems may affect the surgical procedures of removing these implants (3). To overcome to these problems, a conical coupling locking plate system was introduced [4). Aims of our study is to retrospectively evaluate the outcome of a fracture treated by conical locking plate fixation with regards to radiographic healing, complications and difficult to eventual removal in case of different type of fracture, quality of bone and operative technique.

Materials and Methods

This was a retrospective observational cohort study, and the present study was approved by the institutional review board (aslcn prot. 24/19). The medical records and radiographs of patients who underwent open reduction and internal fixation with conical locking plate from May 2013 to December 2017 in two institutions were reviewed.

The inclusion criteria were as follows: surgical treatment with conical locking plate, closed fractures, patients over 18 years of age , fractures treated within 2 weeks. The exclusion criteria were pathological fractures, open fractures, nonunion.

We identified 198 patients with 206 fractures, including 80 wrist fractures (39%), 53 clavicle fractures (24%), 21 malleolar fractures (10%), 18 distal humeral fractures (9%), 9 proximal tibial fractures (4%), 8 olecranon fractures (3%), 6 diaphiseal humeral fractures (2%), 3 periprosthetic femoral fractures, 2 distal femoral fractures, 2 ulnar fractures, 1 proximal humeral fracture, 1 distal tibial fracture, 1 calcaneal fracture, 1 diaphyseal tibial fracture.

The average age was sixty-six years (range 21-86). The majority of the patients were females (males 52, females 154).

In all cases fixation was obtained by O'Nill conical locking plate (Intrauma, Rivoli, Italy). All patients were followed up clinically at two weeks postoperatively, then monthly for 3 months, 2 monthly till the fracture union. At every follow up visit standard radiographs were obtained and thorough clinical assessment done. Postoperative complications included loss of reduction, fragment displacement, deformation or implant-related problems (screw perforation, screw loosening or backing out, plate pullout, or breakage), and surgical and other general complications such as wound infection or soft-tissue problems were recorded. All the radiographic observations in the current study were conducted by an orthopaedic surgeon who is one of the authors.

All patients were treated by standard open reduction and internal fixation according to anatomic segment injured. In all case of diaphyseal simple fracture a compression screw and neutralization plate fixation was performed. In case of comminuted diaphyseal fracture and periarticular fractures a bridge locking plate fixation was performed. O'Nill plate system is composed by a series of anatomical shaped plates to restore original anatomy of the bone. An intermediary bushing-like insert which locks the screw and threads into the plate is placed in all holes. Standard compression screws are positioning into oval holes or into standard hole before bush removal (Fig. 1) Angular stable locking plating is guarantee by a conical coupling locking mechanism between the screw head and

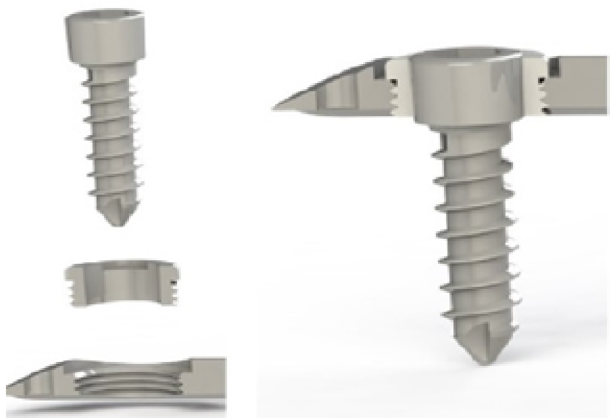

Figure 1. Locking coupling mechanism. Three single components of locking mechanism: conically-head screw, conically shaped bushing inserts with external threads and threaded hole plate (left). Conical screw- bushing insert coupling and threaded bushing insert-plate coupling

bushing insert-plate construct. The bushing-inserts are made of titanium alloy Ti-6Al-4V. The inner surface of the bushing-insert is conically shaped to engage and secure the head of the screw and external threads are present for fixation into the plate. External grooves on the superficial edge of the bushing-insert couple with a designed insert device, an instrument used to thread the insert into and from the support plate.

Therefore, after reduction and plate positioning, the coupling of the screws to the plate takes place through a series of bushings, which allow to maintain fixed angular stability positioning composed by a Morse cone design screws that engages with a titanium bushing insert, which in turn screws into a stainless steel plate working as an internal fixator (Fig. 2).

Results

A total of 198 patients with 206 fractures underwent angular conical stable plate fixation within the observation period. One patient died shortly after surgery because of non-related diagnoses. Ten patients with eleven fractures were lost to follow-up as they did not appear at their outpatient-clinic appointments for unknown reasons. 185 fractures healed within three months. Two cases of infections (one lateral malleolar fixation and one olecranon fixation) were observed, one of which needed early plate removal and brace positioning. Ten complications related to plate fixation were observed (5,1%). Two case of intra-articular positioning of screws of wrist plate. One case of loss of reduction and breakage of wrist plate due to an inappropriate proximal fracture fixation. Five cases of complications involved clavicle fixation: three cases of non-union, one case of peri-implant fracture, one screws loosening and plate medial pull out (Fig. 3-5) . One non-union of distal tibial fracture, one non-union in olecranon fracture were finally observed. Thirty-four patients that have symptoms that could be traceable to the implants in-situ underwent plate removal. Removal concerned 4 wrist plates, 16 clavicle plates, 11 malleolar plates, 1 distal humeral plate, 1 proximal tibial plate, 1 olecranon plate. No complications were observed during surgical plates removal.

Discussion

The are many advantages in angular stability plates used for fractures fixation, as described by Wagner in 2003 (2). The angular stability plate-screw construct is

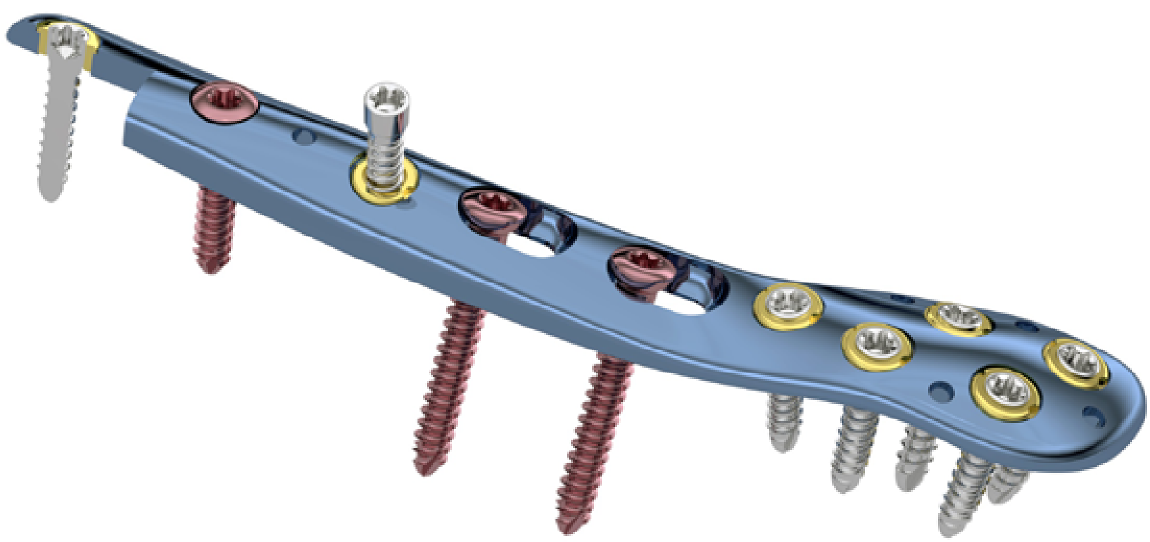

Figure 2. Model of malleolar conical coupling plate: standard dynamic compression screws and locking screws (conical coupling screw- bushing insert)

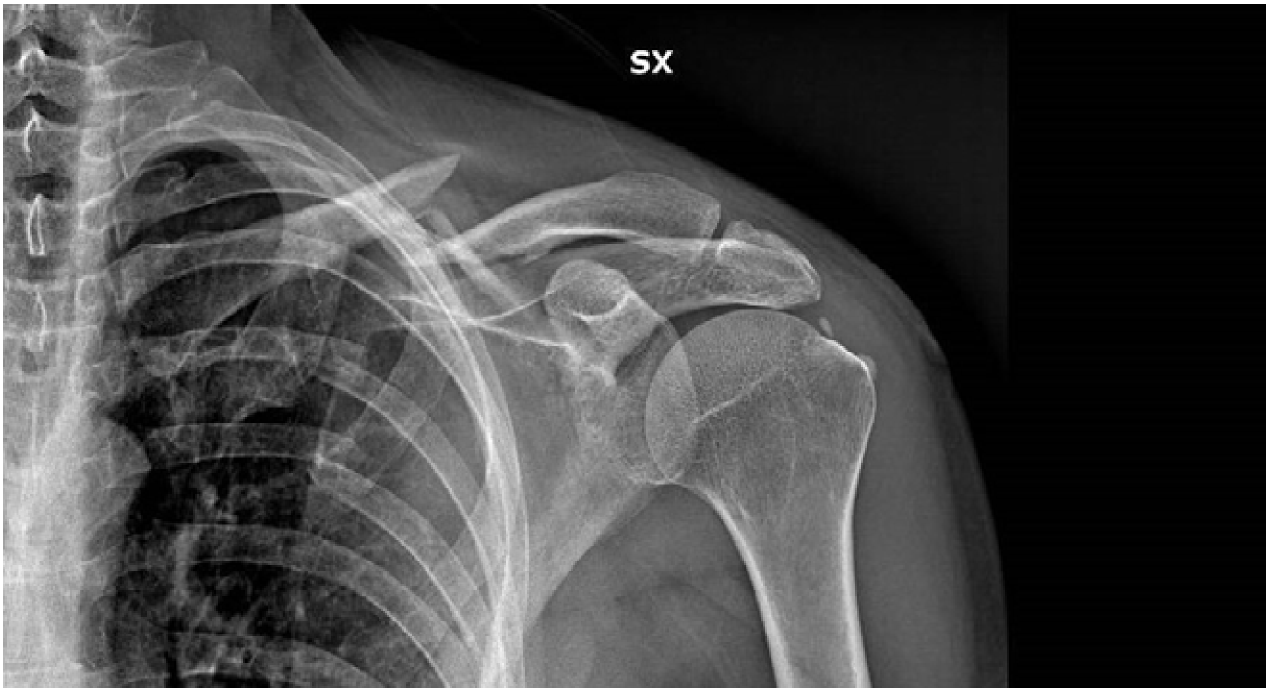

Figure 3. Pre operative radiograph of left clavicle fracture.

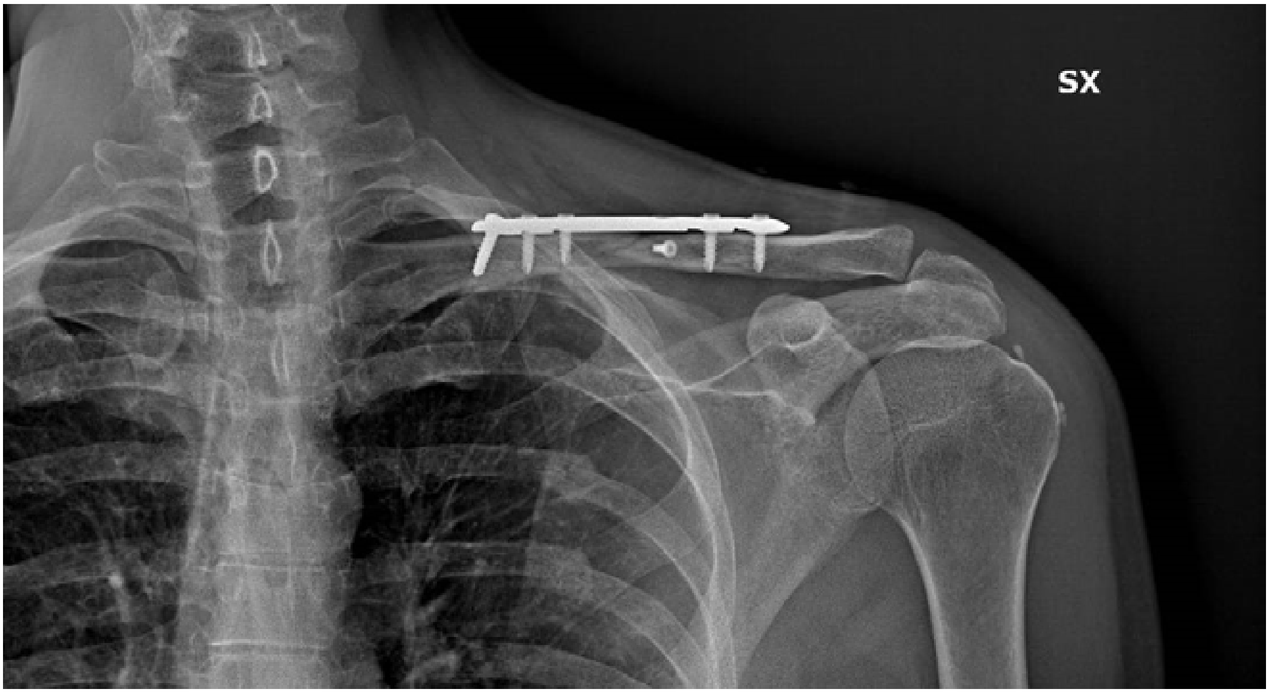

Figure 4. One month post operative radiograph after conical coupling locked plate fixation.

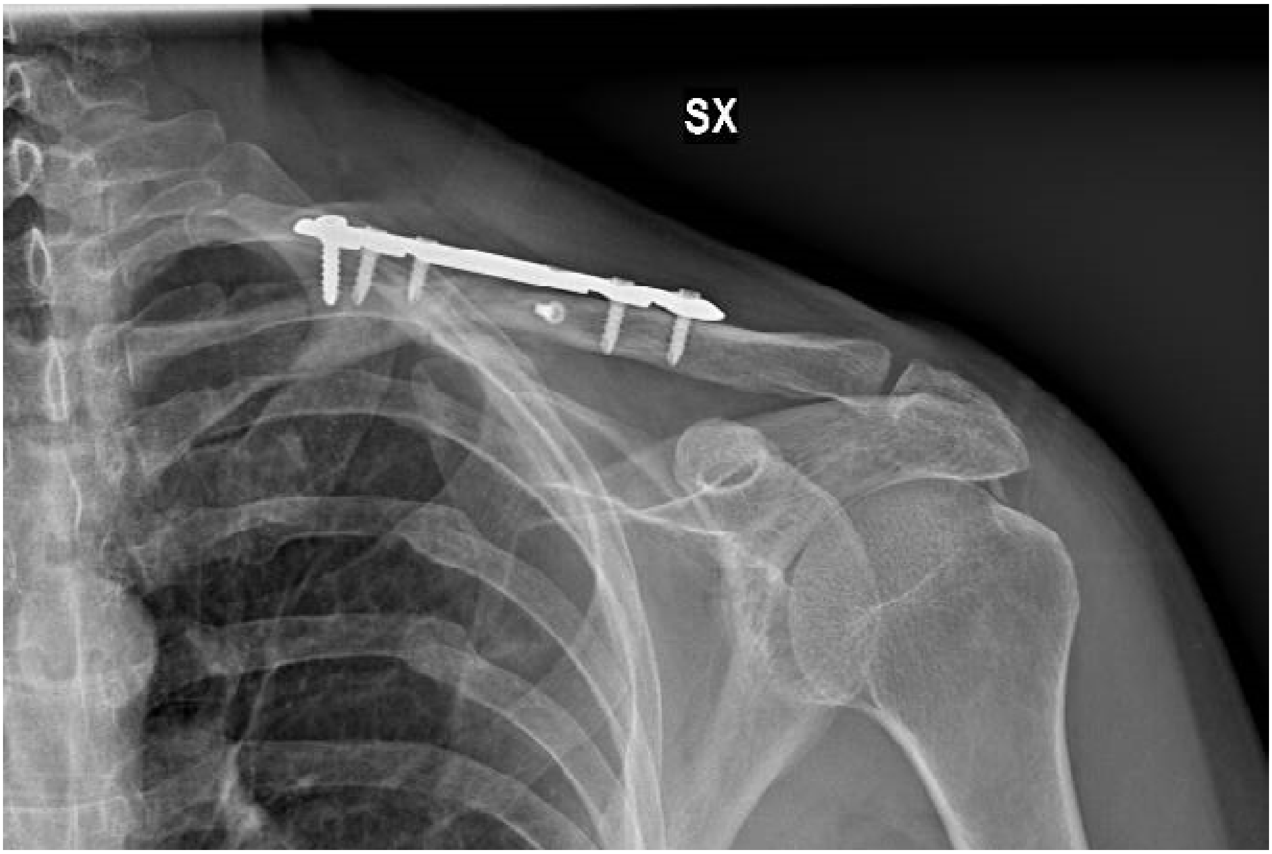

Figure 5. Medial pull out of clavicle plate at 2 months after surgery

intrinsically stable and fracture healing depends on the rigidity of the implant; the compression of the plate on the bone is not necessary and this preserves the periosteal circulation, increasing the possibilities and the speed of fracture healing, reducing at the same time the loss of correction and the possibility of implant mobilization. They can also be used in pluriframmentary fractures or in osteoporotic bone, where absolute stability cannot be achieved with conventional plates (5). Furthermore, there's no need to model, in metaphyseal critical areas such distal radius (6) or proximal tibial plateau (7), allowing the use of such precontoured implants mostly with the MIPO technique. These constructs can be considered as "internal fixators" with the advantage of allowing an elastic internal fixation that strongly stimulates the formation of callus. On the contrary, fixation based on the conventional principle of absolute stability, induce bone healing only by direct osteonic remodeling (or primary ossification), a much slower process than healing with callus. The introduction of angular stability plates has therefore revolutionized the treatment of fractures (1,2).

There are many types of angular stability in screw-plate locking systems (8). The LCP system, for example, has threaded locking holes on the plate that correspond to the thread of the head of the screws that create angular stability. An alternative form of the locking screws mechanism is the Morse cone system, which characterized the PC-Fix system (Point Contact Fixator). The system resistance to torsional and bending forces was comparable to traditional plates (9). This system was not commercialized due to the problem of the jamming of the plate screw which prevented its removal at the end of the healing of the fracture. It was assumed that this problem was due to the excessive torque force at the closure of the screw in the plate (10,11). To overcome this problem, a modification has recently been introduced to the mechanism of the trunco-conical locking angular stability, adding a titanium insert screwed to the plate that locks with the trunco-conical head of the screw (4). In a FEM-based biomechanics study, the forces on the screw head system in this type of system were studied. In this study it is highlighted that the presence of an insert at the level of the mechanism of closure of the screw to the plate creates a better distribution of forces, discharging the critical point of the system, ie the base of the screw head, thus reducing the possibility of stress shielding at the fracture level.

In another biomechanical study based on an animal model (12), the behaviour as an internal fixator of an angular stability LCP plate was compared with the truncated cone stability plate used under the same conditions, in particular if subjected to axial cyclic compression forces. The results of this study defined a greater resistance of the plates with a truncated conical angular stability mechanism compared to the LCP plates, although the design of the LCP plates and the truncated cone angular stability system was different (holes on the body of the LCP plates left empty to create the "internal fixator" system vs holes present only proximally and distally in the plates with angular conical trunk stability system).

The problem of removing an angular stability implant due to cold welding and cross-threading of the threaded screw head in LCP implants is well known, especially in implants with 3.5 mm screws (3). This complication can lengthen the surgical time to remove the plates and screws. The system used in O'Nill plates, in theory, avoids this risk due to the presence of the titanium insert screwed to the plate. The interface between the head and the hole of the truncated-conical plate is removed together with the titanium insert, eliminating the problems of cold welding and cross-threading, thus facilitating the removal of the plates and screws. In our series, no complications or difficult to screw removal was observed during surgical removal.

As regards the clinical results of the use of these types of implants, a single clinical experience is described between 2005 and 2006 on 30 patients (4). In this experience, a single mobilization of an implant was described in an olecranon fracture treated with plate and screws with angular trunco-cone stability, probably linked to an early onset of physiotherapy in an elderly osteoporotic patient. Our experience is comparable to those achieved by this Author. At the same time our results are comparable to those achieved by use of locking threaded plate (4,5,13).

Our study has some limitations. The group of study is not homogeneous, different type of fracture in different anatomical regions are included. But Aims of the present study was to evaluate clinical effectiveness and ease of plate removal of conical coupling locking plates into different scenario regarding quality of bone, type of fracture and type of fixation.

Additionally, no functional results are evaluated, target of the study is only time of radiographic and clinical healing and incidence of complications. Quite the opposite to or knowledge our series of 206 patients represents the largest series of consecutive fracture fixation by conical locking plate reported in literature

Conclusions

Conical coupling angular stability plate represents an attractive alternative to threaded angular stability plate. Bush titanium insert, eliminating the problems of cold welding and cross-threading, simplifies surgical screws and plate removal. Further studies need to evaluate trunco-conical stability plate results in every anatomic bone segment

Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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