Fixation of Osteoporotic Fractures in the Upper Limb with a Locking Compression Plate

Stabilizace osteoporotických zlomenin horní končetiny pomocí úhlově stabilní uzamykatelné dlahy (LPC) – přehled současných přístupů

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SUMMARY

Locking Compression Plate (LCP) has the advantageous feature that screws can be locked in the plate leaving an angular stable construct. There is no need to have contact between the plate and the bone to achieve stability resulting from friction of the plate-bone-construct. Therefore the plate does not need to be contoured exactly to the bone and the healing bone’s periosteal blood supply is not affected. The LCP is used as a bridging plate to gain relative stability in multi-fragmentary, diaphyseal or metaphyseal fractures. Depending on the fracture, the combination hole can also allow the LCP to achieve absolute stability similar to conventional fixation techniques.

Osteoporotic fractures have significant impact on morbidity and mortality. Proximal humeral and distal radius fractures are typical examples. These osteoporotic and often comminuted fractures are ideal settings/indications for LCP utilization in the upper extremity. However, the data quality is due to mostly small study populations not so powerful. Unquestionably there has been a clear and fashionable trend to choose operative treatment for these fractures, because the angular stability allows stable fixation and early functional mobilization.

Key words: concepts, current, fractures, Locking Compression Plate, osteoporotic, review.

INTRODUCTION

Reconstruction of complex fractures and nonunions in the upper limb in the elderly patient with underlying osteoporosis and prior to the development of the Locking Compression Plate (LCP) was challenging (20, 23). The development of LCP in the last ten years has dramatically changed the treatment not only of distal radius and proximal humeral fractures, but also of complex fractures and nonunions (Fig. 1a–f). This article will present an overview about the principles of LCP and the current concepts utilizing LCP in treating osteoporotic upper extremity fractures.

LCP

Locking Compression Plate (LCP) has the advantageous feature that screws can be locked easily in the plate achieving an angular stable construct. There is no need to have contact between the plate and the bone to get stability resulting from friction of the plate-bone-construct (42). As a consequence the plate does not need to be contoured as exactly as possible to the bone. Another advantageous aspect of this technique is that the healing bone’s periosteal blood supply is not affected. The LCP is broadly used as a bridging plate to gain relative stability in multi-fragmentary diaphyseal or metaphyseal fractures. An open approach is possible, but a less invasive, as in MIPO (minimal invasive plate osteosynthesis), is preferred and affords less harm to the soft-tissue coverage. The reduction is mostly achieved by indirect means. Yet there are important features to be considered according to Gauthier and Sommer (12). First the plate must be of appropriate length. The proportion of plate length and fracture length has to be considered. They concluded that the plate length should be 2 to 3 times the fracture length in comminuted fractures and 8 to 10 times in simple fractures. Second the plate must be positioned well, so that all the screws can be adequately positioned in the bone to maximize anchorage of the bicortical screws. Third the appropriate number of screws is needed, usually three on each main frag-
ment. One last issue is the complete loss of the surgical feeling of the quality of the bone during screw insertion and tightening.

Depending on the fracture, the combination hole can allow the LCP to achieve absolute stability similar to conventional open reduction and internal fixation techniques using Low Contact Dynamic Compression Plates (LC-DCP). The main indications therefore are articular fractures or simple diaphyseal (AO type A) fractures (42). However, a precise contouring is mandatory in this situation. In osteoporosis the loss of reduction is often encountered with conventional plate-screw-bone-constructs due to the thin bone cortex and consecutively short working length of the screws in the cortex (12). This leads to malalignment and in the case of instability to nonunion. A combination of conventional and locking screws is possible and is showed in diagram 1. Anatomical reduction is achieved with the precise contoured plate and conventional screws. Supplementary locking head screws improve the pullout forces of the osteosynthesis and the resistance against bending and torsion.

Another example of the combination of conventional and locking screws is the use of absolute and relative good bone quality osteoporotic bone.

Fig. 1a-f. This 38-year-old patient had a complete amputation of his arm and had a replantation four years ago. He presented to our office with this complex nonunion of the left distal humerus. Radiographs are showing the peri-operative sequence of events and treatment (open reduction and internal fixation nonunion with anterior and posterior capsular release). After two years he can do pushups and the x-rays show good healing of the nonunion.

Diagram 1. In osteoporosis loss of reduction is often encountered with conventional plate-screw-bone-constructs due to the thin bone cortex and consecutively short working length. A combination of conventional and locking screws is possible. (Reprinted from Injury, Int. J. Care Injured, Vol 34, Michael Wagner, General principles for the clinical use of the LCP, Page No. S-B35, Copyright (2003), with permission from Elsevier).
stability in articular fractures with extension into the diaphysis (42). The articular component can be fixed with absolute stability using conventional screws whereas the metaphyseal / diaphyseal part is bridged (relative stability) while adhering to the locking compression technique.

LCP is mainly used in proximal humeral, distal radius, distal ulna, peri-articular metacarpal, phalangeals, osteopenic, or comminuted / multifragmentary diaphyseal fractures, and reconstructions in case of nonunion and malunion (37). In the next section we focus on a few of these topics

**Osteoporotic fractures**

Osteoporotic fractures have significant impact on morbidity and mortality as well as social and economic implications (2, 10, 14, 44). Patients with osteoporotic fractures have also an increased risk having a second fracture in the future (10). Typical osteoporotic fractures of the upper extremity are proximal humeral and distal radius fractures. The lifetime risk of suffering a proximal humeral fracture is nearly 14% in a standard European city (25). The risk for distal forearm fractures (22%) is higher in women while the risk in men is usually lower than 6%. The prevalence of osteoporosis in women with distal radius fractures can be as high as 34% (31). Because it is considerably higher compared to control groups it may therefore be seen as a risk factor for these fractures. These fractures occur classically in elderly patients after a fall and subsequently from the direct fracturing impact (32).

Elderly patients are best served by rapid, definitive fracture care allowing mobilization. The fixation of these osteoporotic bones may therefore call for modifications of plate fixation (longer plates, blade modification, cement, 6.5 mm cancellous screws, or allograft struts) (Fig. 2a–e). Especially osteoporotic and often comminuted fractures are ideal indications for LCP in the upper extremity (40) (Fig. 3a–c). LCP therefore has greatly influenced the treatment of these fractures. Because of the angular stability it allows stable fixation and early functional mobilization.

Osteoporosis, the stability of the osteosynthesis in osteoporotic fractures, soft tissue quality, comorbidities, and the age of these patients can impair bone healing (5, 13). Bisphosphonates (up to 5 years) and calcium-supplements are therapeutic and preventive in osteoporosis. Therefore they can reduce the overall risk of fractures, however the effect on bone healing is controversial. In addition, long-term bisphosphonates can promote atypical femoral fractures as recently published data shows, but the absolute risk is small (38, 39).

Proximal humeral fractures

Hertel emphasized the main difficulties in proximal humeral fractures as there being a weak bone, a tendency towards comminuted fractures, and reduced patient’s compliance (17). These issues are ideal indications for locking plates as discussed earlier.

Neer distinguished fractures with no or minimal displacement (Neer I) versus displaced fractures (displaced more than 1 cm or angulated more than 45 degrees). The displaced fractures are - based on the fracture localization and the amount of segments - further subdivided (Neer II - VI) (29). As a basic principle non or minimally displaced proximal humerus fractures can be treated non-operatively with excellent or good results in nearly 90% (11). In contrast, conservative treatment of displaced proximal humeral fractures can lead to a worse outcome. Therefore the number of fragments and their displacement influences the decision to proceed with operative treatment. The indication for operative treat-
However, the reoperation rate was 29%. This high reoperation rate is consistent with other studies (16, 18, 43). Screw penetration, varus fracture collapse, subacromial impingement, and loosening of implant were mentioned as indications for revision surgery (33, 34, 40). Screw penetration in 16% was the major complication in a retrospective analysis. We agree with the authors that the appropriate number and length of screws are of great importance (8). More displaced fractures, initial varus fracture configuration and reduced head vascularity were the main risk factor for failure (16). In addition to the high reoperation rate, up to 18% can demonstrate a fair result due to pain or restricted abduction. The most predictive factors for these insufficient results were revision surgery and increasing age (18). Additionally, studies from Norway and Sweden showed no functional benefit after one year of operative treatment even in displaced proximal humeral fractures (9, 45).

As a result, the complication and reoperation rates need to be estimated in every patient. The indication to proceed with surgery is crucial and as mentioned by Yang et al. that larger study cohorts are needed to better crystallize the ideal indications (43).

Hemiarthroplasties are usually indicated in non-restorable situations (complex head split fractures, osteoporosis, avascular head) and as a salvage option. One study compared the 2-years results of hemiarthroplasty versus non-operative treatment of displaced 4-part proximal humeral fractures in elderly patients. The quality of life was significantly higher in the hemiarthroplasty group due to less pain, but the range of motion was similar (30).

**Distal radius fractures (Fig. 4a–f)**

Distal radius fractures have a great impact on functional independence in elderly patients. Casting of distal radius fractures affected functional outcome in older patients more than in younger patients. The functional outcome as well as the satisfaction but not the x-ray were yet similar for open reduction and internal fixation vs. casting in unstable distal radius fracture in elderly people after a follow-up period of one year (1).

To proceed with the ideal treatment, it is fundamental to understand the fracture pattern as well as the patient. Different classification-systems evolved over time and greatly help us to improve the comprehension of these fractures and their stability. The fracture stability and reduction, the presence of associated injuries and patient factors mainly guide the treatment (19). However the treatment is debatable, the trials lack adequate power and the indication to operate is beyond the focus of this review (21, 27). Unquestionably there has been a clear trend towards operative treatment of distal radius fractures.

Before the development of LCP the dorsal approach was preferred for dorsally displaced distal radius fractures. The conventional plate was used as a buttress plate. Additionally a dorsal incision of the joint capsule allowed visualizing the adequacy of the open reduction of
intra-articular fractures. However, the positioning of the plate can cause tendinitis and tendon ruptures and are therefore often removed typically after six months (26). Currently, the dorsal approach is rarely used and the main indications are displaced dorso-ulnar fragments, need for repair of carpal ligaments, and articular surface reconstructions. For the volar approach, the incision is made between the flexor carpi radialis and the radial artery, then the pronator elevated and the fracture identified, reduced, and fixed.

A biomechanical study showed superiority of volar locked plating versus dorsal non-locked plating in distal radius fracture (3). These results are more distinct in osteoporotic fractures (24). A recent study comparing volar versus dorsal approach and internal fixation with locking plates in 305 patients revealed an earlier and better functional outcome in the volar group (27). However, the complication rate in the volar treated group was considerably higher (15% vs. 5%). Mostly transient soft tissue / wound problems were encountered. Loss of reduction, malunion, and nonunion were encountered in less than 3%.

The choice of the plate most likely does not affect the outcome. A study comparing a titanium 2.4 mm pre-contoured plate with that of a stainless-steel oblique 3.5 mm T-shaped plate revealed similar results (41). The main goal in operative treatment is definite and stable fixation of the fracture. The most important provider of stability in volar plate fixation remains yet the subchondral positioning of the screws (6). More screws seem also more stable in osteoporotic bones. Loss of volar tilt as a consequence of malpositioned screws can cause reduced range of motion, incongruity of the distal radioulnar joint as well as flexor tendon ruptures due to the more prominent plate (7, 36). A volar plate should therefore not overlap the Watershed line. A second plate right-angled to a volar plate as well as bone substitute (allograft and cement) may improve further the stability.
As a summary, Mudgal and Jupiter stated that locking plate fixation of distal radius fractures can have satisfying outcome even in the face of osteoporosis (28). In the active elderly population there is an acceptable complication rate to justify open reduction and internal fixation for appropriate fractures. Osteoporotic bone does not preclude internal fixation. And they usually have good (functional) outcomes.

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