Mod Rheumatol (2005) 15:169–172
DOI 10.1007/s10165-005-0392-z

REVIEW ARTICLE

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Locking compression plating: a new solution for fractures in rheumatoid patients

Received: January 17, 2005 / Accepted: February 7, 2005

Abstract Osteoporosis is a well-known phenomenon in rheumatoid arthritis (RA) that is characterized by marked loss of peripheral bone. It was found that the frequency of osteoporosis in RA can be increased significantly compared with the reference population, which implies a higher risk of fracture in this group of patients. Osteoporosis makes the treatment of fracture in RA patients more challenging, including the difficulty of fracture fixation, delayed union, secondary loss of reduction, and fixation failure. The locking compression plate was designed using the concept of "internal fixator," which provides a new solution for the fixation of osteoporotic fractures. The fixed angle between the screw and the plate increases the pull-out strength of the system, so the stability of the fixation no longer depends totally on the quality of the bone. The other benefits of this system include the fact that no accurate contouring is required, it protects the local blood supply, and it supports minimally invasive plate osteosynthesis.

Key words Fracture · Internal fixation · Locking compression plate (LCP) · Osteoporosis · Rheumatoid arthritis (RA)

Introduction

Rheumatoid arthritis (RA) is an autoimmune disorder of unknown etiology characterized by symmetrical, erosive synovitis and in some cases extraarticular involvement. In China, it affects about 0.32%–0.34% of the population (more than 4.1 million people). On the other hand, the low prevalence also means that average surgeons usually develop little experience with its diagnosis or management.

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Osteoporotic fracture and rheumatoid arthritis

Osteoporosis is a well known phenomenon in RA, the prevalence being 0.1%–0.2% in men and 0.2%–0.5% in women.[1,2] Surveys done in Sweden and Norway, which included 104 male and 394 female RA patients, showed that the rate of bone mineral density (BMD) decreases and the prevalence of osteoporosis can be as high as twofold that of normal people.[3] The osteoporosis in RA is characterized by localized bone loss in the form of bone erosions and periarticular osteopenia, which constitutes an important radiographic criterion for the diagnosis.[4] Unlike postmenopausal osteoporosis, RA shows relatively preserved bone mass in the axial bone and marked loss in the peripheral bone, which is also detectable early after onset. In a cross-sectional and longitudinal study of osteoporosis in RA patients, there was significantly lower BMD in the mid-radius and calcaneus of the RA group than of the OA group, whereas the lumbar spine showed no significant difference.[5] It was found that the frequency of osteoporosis in RA may be increased twofold over that of the reference population.[6] Recent research by Lodder et al.[7] regarding BMD data from patients with low to moderately active RA demonstrated an association between significant radiological RA damage and low BMD at the hip, which suggests a correlation between the severity of RA and the risk of generalized bone loss.

Osteoporosis in RA is characterized by a complexity of risk factors, including primary osteoporosis risk factors as well as inflammation, immobilization, and use of corticosteroids. The osteoclast was proved to have a crucial role in RA, inducing structural joint damage (erosion) and high-turnover osteoporosis.[8] The latter may lead to increased risk for fracture and result in delayed fracture healing if it happens. Subjects with RA have at least a twofold increased risk of osteoporotic fracture.[9] The annual prevalence of fracture in RA patients has been reported to be 2.7%; and Huusko et al.[10] reported a threefold increased risk of hip fractures in patients with RA.

The presence of osteoporosis makes treatment of fractures in RA patients more difficult. Such difficulties include *screw loosening*. As we know, the stability of standard screw–plate fixation depends on bone quality. In the case of porous bone, the screw-holding power is not sufficient, leading to tilting or loosening of the screw. For the same reason, *fixation failure* easily occurs under such stress. Also, the pull-out force of screws in porous bones is prominently reduced, often leading to *secondary loss of fixation*.

Biomechanism of the locking compression plate

The idea for a locking compression plate (LCP) arose during the late 1990s. The name of this device came from the design of its screw hole, which combined a locking hole and a conventional dynamic compression hole into one unit. When we talk about the LCP, we say it is not only a plate but also a concept, as the LCP combined two mechanisms of fixation: internal fixation and compression plating.[11] Mostly, LCP was used like an internal fixator. Therefore, when we use this plate, the application principle is more like that of the external fixator.

As we know, with standard plate fixation, the stability of the system depends on the friction between the plate and the bone. When the screw is tightened, the plate compresses the cortex of the bone, which produces the friction that maintains the stability of the system. The stability of a standard screw depends on bone quality. In the case of porous bone, the holding power of the screw is not sufficient, which makes the screw tilt or loosen, leading to failure of the whole system (Fig. 1). With the LCP, the screws lock into the plate, so the stability of the system no longer depends on the friction between the bone and plate. The stability of the screw no longer totally depends on the quality of the bone. The screw–plate system can resist the load by itself without the friction between bone and plate. The screws do not easily tilt or loosen under the axial load even in porous bone (Fig. 2). For the same reason, no accurate contouring is necessary because the fixation no longer depends on the friction between the bone and the plate. For a regular plate–screw construct, the pull-out of the system usually results under a bending load. Under this load, the screws are subsequently pulled out (Fig. 3). The angular stability of the screws largely increases the area of resistance, which increases the resistance of the locking screws to the bending load (Fig. 4). With the LCP, if the constructs were to be pulled out, the screws should be pulled out simultaneously. The lowest resistance to pull-out occurs when the screws are loaded in a purely axial direction, which is rare in the clinical situation. Regular compression screws must be placed bicortically to achieve sufficient stability. If compression screws are fixed only in the near cortex, the frame of stability is not closed and the load applied to the bone can force the unicortical screws to rotate in the plate holes (Fig. 5).

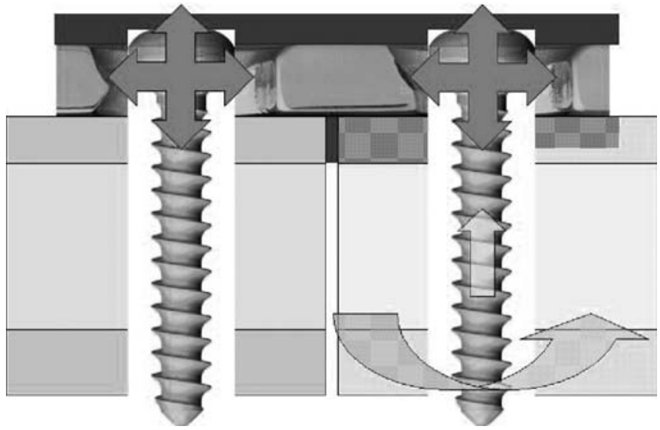

Fig. 1. The stability of a standard screw depends on the bone quality. In the case of porous bone, the holding power of the screw is not sufficient, which makes the screw tilt or loosen, leading to failure of the whole system

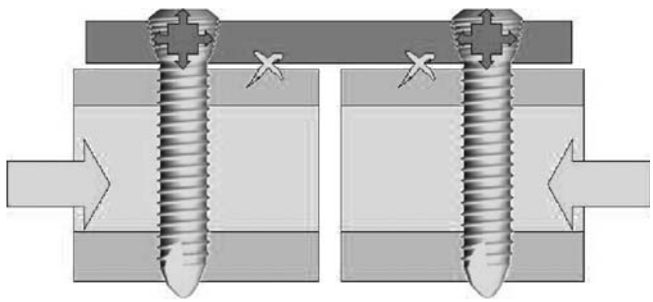

Fig. 2. The stability of the locked screw in the locking compression plate (LCP) no longer totally depends on the quality of the bone. The screw–plate system can resist the load without friction between bone and plate

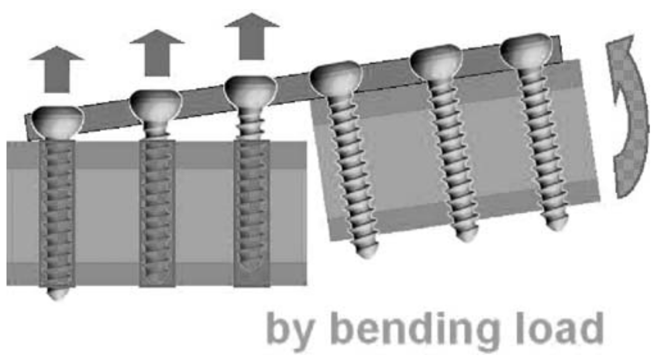

Fig. 3. For a regular plate–screw construct, screws are pulled out subsequently under bending stress

Locked screws in the LCP can be placed unicortically because the frame of stability can be closed by the plate as part of the frame. It is impossible to tilt the unicortical locked screws under loads (Fig. 6).

Because the stability of the system in the LCP no longer depends on friction between the bone and the plate, the

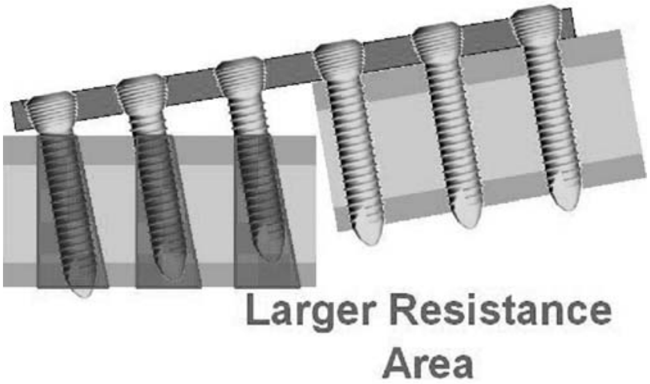

Fig. 4. The angular stability of the locked screws in the LCP largely increases the area of resistance, which provides higher resistance of the locking screws to bending loads

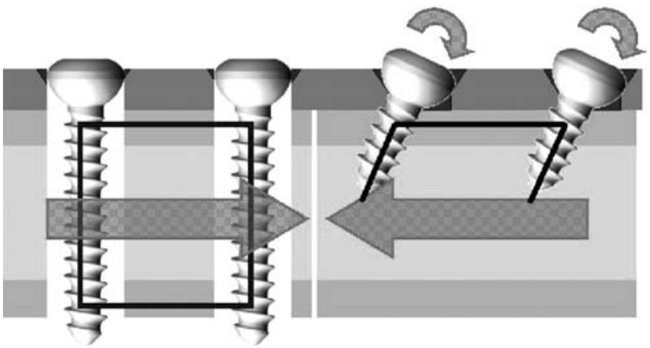

Fig. 5. If conventional screws are fixed only in the near cortex, the frame of stability is not closed and load applied to the bone can force the unicortical screws to rotate in the plate holes

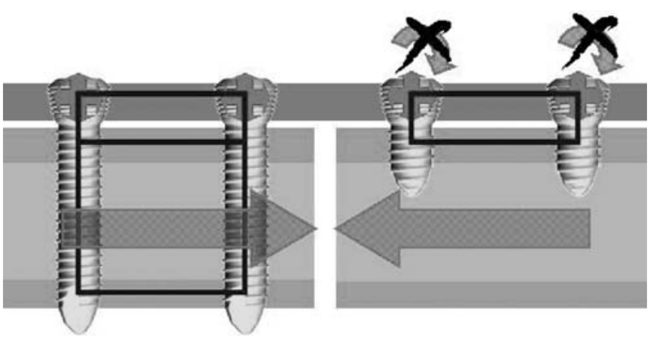

Fig. 6. Locked screws can be placed unicortically because the frame of stability can be closed by the plate as part of the frame. The unicortically locked screws thus cannot tilt under load

plate no longer compresses the surface of the bone. Hence, the perisoteum between the bone and the plate is well protected, which significantly improves the biological environment for fracture healing.[12]

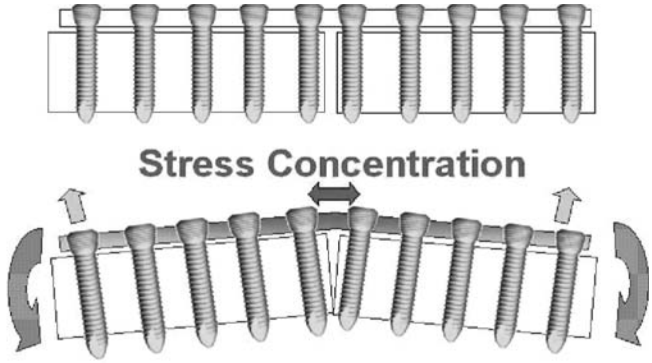

Fig. 7. Stress easily concentrates at the fracture site when the fracture is fixed with the LCP, as the area there has less flexibility

Principles for clinical use of the LCP

The locked internal fixator technique with the LCP allows but does not generally require precise reduction. Non-compressed plates, nails, and fixators are splints. The technique for the internal fixators with the LCP is similar to that for the external fixator; that is, it fixes the fracture in a relative stable way.[13] The aim of the LCP technique is to preserve the natural biology, similar to that of the external fixator. It is inherently simple but requires an open-minded approach to this new method and philosophy. The LCP resembles a plate but functions more like an external fixator that is fully implanted. This procedure supports biological internal fixation, that is, a type of internal fixation that gives priority to biology over mechanics.

There are various indications for using the LCP during several techniques and biomechanical principles. The most common use for the LCP in minimally invasive (percutaneous) plate osteosynthesis (MIPO/MIPPO) for bridging the fracture site. This need arises in the following situations: (1) multifragmentary fractures in the diaphysis and metaphysis; (2) simple fractures in the diaphysis; (3) open-wedge osteotomy; (4) secondary fractures after intramedullary nailing; (5) periprosthetic fractures; (6) delayed change from external fixation to definitive internal fixation. The LCP can also be used in a combination of compression plating and internal fixation, which is usually applied to: (1) articular fracture combined with a multifragmentary fracture or (2) a segmental fracture with two fracture patterns. Finally, the LCP can be used as a conventional compression plate, which is beneficial in osteoporotic situations.

Because the biological mechanism of the LCP is different from that of the conventional plate, there are some special factors to note when implanting the LCP. When the LCP is used as an internal fixator, the bridge-plating technique can be applied with an open approach or a minimally invasive percutaneous plate osteosynthesis (MIPPO) approach. The locking mechanism between the plate and the screw makes the LCP a rigid system, so stress concentration may easily occur at the fracture site (Fig. 7). Therefore, when using the LCP, a long plate and adequate spacing

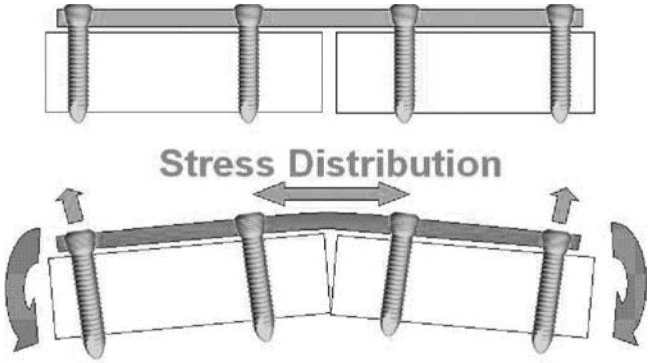

Fig. 8. A longer plate leaves an area of flexibility, thereby avoiding concentration of stress

between the locking screws are required. It is important to leave two or three plate holes at the fracture site free to avoid stress concentration (Fig. 8). Monocortical screws are sufficient for axial loading in good-quality bone, but it is comparatively weak for rotational stress.[14] In a situation with more rotational stress (e.g., in the humeral shaft), at least one bicortical locked screw is recommended on each side of the fracture. At least two bicortical screws are recommended on each side of a fracture in severe osteoporotic bone.

Conclusions

The LCP combines two kinds of biomechanisms and techniques into one implant. It is especially beneficial for the treatment of osteoporotic fractures, which is a common situation in RA patients. Surgeons must understand its biological mechanism and carefully consider the indications and method of fixation before implanting the LCP.

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