ANALYSIS OF LOCKED COMPRESSION PLATING IN OSTEOPOROTIC FRACTURES-PROSPECTIVE STUDY

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ABSTRACT

BACKGROUND

Fractures in osteoporotic bones pose challenges to the treating orthopedists due to the complex problems in fixation of osteoporotic bones.[1,2,3,4] Failure of treatment usually results due to less bone purchase, implant failure and insufficient callus formation. The locking compression plate (LCP) was devised by combining the features of an LC-DCP (Limited Contact-Dynamic Compression Plate and a PC-Fix (Point Contact Fixator). Thus, LCP gives a better solution to this complex situation of management of osteoporotic fractures.[5,2,3,4]

The aim of the study is to analyse the functional outcome of locked compression plate fixation in osteoporotic fractures of both upper and lower limbs.[6,2,3,4]

MATERIALS AND METHODS

The study was conducted in Govt. Medical College, Kottayam, Kerala over a period of seven years from 2006 to 2013. The study included 480 osteoporotic fractures whose BMD was assessed in pelvic X-rays based on Singh's index and internal fixation was either by open method or by minimally invasive method using LCP.[7] The study included 380 male patients and 100 female patients who had osteoporotic bones due to various causes.

The ages of the patients varied from 48 years to 74 years (mean age was 61 years), of which 288 patients (60%) were from 40 to 60 years of age and 192 patients (40%) were 60 years or more. Average duration of healing, complications and its rate, post-operative rehabilitation time all were assessed.

RESULTS

We have high union rates in our series of 480 pts with osteoporotic fractures, but not without complications; the complications were- 1) Superficial infection in 32 cases (6.66 %); 2) Deep infection 24 cases (5%); 3) Delayed union 14 cases (2.91%); 4) Malunion in 12 cases (2.5%) amounting to a total of 82 cases accounting for (17%) in total.[1]

CONCLUSION

Fixation of fractures using LCP has proved to be an efficient treatment alternative in osteoporotic fractures with excellent union rates.[6,2,3,4] Complications though present are nevertheless not significantly higher than the existing implants like DCP LC-DCP etc. Moreover, superficial infection is a negligible complication as it can be adequately simply managed.

KEYWORDS

Biological Fixation LCP, Locking Head Screw, Locking Screw Hole, Osteoporotic Fractures.

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BACKGROUND

Fractures in osteoporotic bones pose challenges to the treating orthopaedists due to the complex problems in fixation of osteoporotic bones.[2,3,4] Osteoporotic bones are abnormally porous and bone mass per unit volume of bone tissue is less than normal and hence its strength is less than normal for a person of that age and sex. Failure of treatment in osteoporotic fractures usually results due to less bone purchase of the screws, implant failure and insufficient callus formation.

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Earlier all the fractures including osteoporotic ones were treated by Dynamic Compression Plate (DCP) fixation and occasionally by Limited Contact DCP (LC-DCP).[5] These devises had its inherent deficiency when used in osteoporotic fractures due to the weak purchase of the screws and the associated implant failure due to screw loosening. The locking compression plate (LCP) was devised by combining the features of an LC-DCP (Limited Contact- Dynamic Compression Plate and a PC-Fix (Point Contact- Fixator).[5] Each of the combi-holes of LCP allows insertion of either a conventional screw or a locking head screw, as it has features of both a smooth sliding compression hole and a threaded locking hole. Ever since the introduction of this implant in treatment of fractures in around 2010 there has been regular innovations and modifications. The initial short comings of the implant were step by step corrected in the further improvements in its design; the most noteworthy change is the low-profile plates which helped in overcoming the undue prominence of the plate under the skin and other soft tissues especially in relatively sub cutaneous locations.

LCP has the following solutions to the problems of DCP and additional advantages because of the peculiarities in design apart from overcoming the problem of inferior purchase.[4]

Structured Undersurface

LCP has structured undersurface with groves in the undersurface of the plate which are of adequate depth and width. This significantly improves the blood supply of plated bone segments. This has led to the disappearance of osteoporosis on the undersurface of the plate.

Callus Bridge

The peculiar design of LCP creates a gap between the plate and bone adjacent to the fracture so that circulation is not affected, and a small bridge of callus develops in this critical zone which adds to the strength of the bone.

Undercut Screw Holes

Each screw hole has been fitted out with oblique undercuts both ends. This allows a screw to be tilted up to 40 degree in each direction of long axis of the bone

Uniform Spacing of Screw Holes

This eliminates middle segment and allows for easy shifting of plates in long axis as well as easy changes in plate length.

Trapezoidal Cross Section

Trapezoidal cross section of the plate, with smaller surface of contact with the bone result in the formation of lower and broader bridges of bone along the length of the plate than those previously observed with rectangular cross section.

- Both conventional cortical as well as cancellous bone screws can be applied to the locking plate apart from the locking head screws. Rectangular construct even with unicortical fixation, though not advised in osteoporotic bones gives adequate fixation.
- Unicortical locking screws can also give satisfactory fixation which facilitates better vascularity.

There is neither loss of primary reduction nor even a little chance of secondary loss of reduction when using LCP based on the implant design.

MATERIALS AND METHODS

Fractures of only osteoporotic bone were considered. This was based on the age, initial assessment as per the x-ray appearance, and corroborating with Singh's index as per the evaluation of pelvic X rays.[7]

Unbiased and appropriate patient selection is important; in our series only patients with osteoporotic fractures were considered; patient selection was otherwise on random pattern. Majority of patients was over the age group of fifty years. Radiological assessment was used for determining the presence of osteoporosis in a particular bone though age was in most cases corroborative.

A reduction in at least 30% decrease in bone mass is needed to detect radiologically.

Quality of bone and degree of osteoporosis is determined by-

- Singh's index Grades osteoporosis/osteopenia based on the ordered reduction in trochanteric, tensile and ultimately primary compressive trabeculae in trochanter and in neck of femur where definite osteopenia is identified in the presence of thinned trabeculae with a break in principal tensile group to higher grade 1 where only primary compressive trabeculae are visible.

Singh's index of grading of osteoporosis has its own limitation. It is a week tool in assessing the grade of osteoporosis. Further it depends much on the quality of X-rays.

Ideal tools for measuring Bone Mineral Density (BMD) include RA (radiographic absorptiometry, QUS (qualitative ultrasound), DPA (Dual photon absorptiometry) QCT (quantitative computerized tomography) and DEXA (dual emission X ray absorptiometry).[7] These were not the tools in our study in assessing osteoporosis due mainly to non-availability in our governmental institution and patient's non-affordability for doing outside being from a lower socioeconomic stratum. Another hurdle is the restriction by the ethical committee on costly investigations or treatment in research studies. Our study population consisted of 48 patients (10.0%) in grade 1 as per Singh's index and 432 patients (90%) in grade 3 Singh, s index. All of the patients were restricted to either of the above two grades based on Singh's Index as shown in the table below.

Singh's Index	Number	Percentage
Grade I	48	10.0%
Grade III	432	90%

Table 1

Surgical Techniques

1. Screw Selection

The 5.0 mm Locking Screws with 4.3 core diameter were suitable for both diaphyseal and metaphyseal fractures. The 5.0 mm locking screw was designed as the principle screw for use with LCP. It provides greater bending and shear strength than 4.0 mm locking screws. 5.0 mm locking screw has a core diameter of 4.3 mm and 4.0 mm locking screw provides core diameter of 3.4 mm.

2. Plate Selection

Figure 1. 3.5 mm LCP

The plates were available in various lengths and configurations. If necessary, one could use a bending template to determine plate length and configuration, but it was not used due to non-availability.

3. Contouring

Plate bending devises were used to contour the locking compression plate to the anatomy of bone. The LCP plate holes have been designed to accept some degree of deformation. Significant distortion of the locking holes will reduce locking effectiveness.

4. Reduction and Temporary Plate Placement

The plate was temporarily held in place with threaded plate holder. The plate holder may also function as an insertion handle for use with minimally invasive plating techniques. The middle of the plate was positioned over the fracture.

5. Screw Insertion

Decision as to whether conventional cortex screws, cancellous bone screws or locking screws to be used was taken depending on fracture pattern for fixation. A combination of all were used in some cases.

When a combination of cortex, cancellous and locking screws was used, a conventional screw was used first to pull the plate to the bone. When a locking screw was used first, care was be taken to ensure that the plate was held securely to the bone to avoid spinning of the plate about the bone during final tightening.

Insertion of a cortical or cancellous bone screw.

We used the 2.5 mm drill bit and 3.5 mm tap for 3.5 system conventional screws and 3.2 drill bit and 4.5 mm tap for 4.5 system conventional screws in situations where a conventional screw was used.

Neutral Insertion of a Conventional Screw

Figure 2. LCP with Drill Sleeve in Situ

When pressing the universal drill guide into the DCU portion of the LCP plate hole, it will center itself and allow neutral predrilling.

Dynamic Compression, Eccentric Insertion of a Cortex Screw

Figure 3. LCP with Drilling Device

To drill a hole for dynamic compression, place the universal drill guide eccentrically at the edge of the DCU portion of the LCP plate hole, without applying pressure. Before inserting the first locking screw, we performed anatomical reduction where it was readily possible and fixed the fracture with lag screws where it was necessary. (After the insertion of locking screws, an anatomical reduction will no longer be possible without loosening the locking screw).

Figure 4. Screw the Appropriate Threaded Drill Sleeve for 4.0 mm and 5.0 mm Screws into an LCP Plate Hole

Figure 5. The Appropriate Drill Bit 3.2 mm for 4.0 mm Screws and 4.3 mm for 5.0 mm Screws were Used to Drill to the Desired Depth

The drill sleeve was then removed.

Figure 6. The Depth Gauge was used to Determine Screw Length

We had no facility for using a torque limiting screw driver which is operated mechanically to insert and fix the screws, so the problem of cold welding did not occur.

Post-operative Management

Post-operative treatment with locked compression plate does not differ from conventional internal fixation procedures. All patients were provided with a POP slab for two weeks for facilitating soft tissue healing. Suture removal was usually done on the tenth day. After the operation, each case was followed up once in every two weeks in the first month and once every month thereafter. Additional visits were advised if needed. Perhaps the difference in management of patients in osteoporotic bones is the early mobilization of the operated limbs. Mobilization of the extremities was done immediately after the removal of the slab after second week. Functional evaluation was done at every visit and once in every two months after fracture union.

RESULTS

Surgical and Radiological Photographs

Figure 7. Intra Operative Photograph of Applying LCP

Figure 8. Locked Compression Plate in Situ, Tibia

Figure 9. Comminuted Supracondylar Fracture Femur – AP View

Figure 10. Comminuted Supracondylar Fracture Femur - Lateral View

Figure 11. Comminuted Supracondylar Fracture Femur - AP View 4 Months after LCP Fixation

Figure 12. Oblique Fracture both Bones Forearm Fixed with 3.5 LCP – Intra Operative View

Figure 13. Post-operative X-ray of Comminuted Distal End of Tibia Fixed with LCP Bridge Plating

Figure 14. Pre-Operative X-ray of Long Oblique Distal End of Tibial Fracture

Figure 15. Post-Operative X-Ray of Long Oblique Distal End of Tibial Fracture Fixed with LCP Bridge Plate

Figure 16. Pre-Operative X-ray of Fracture of Proximal Shaft of Humerus

Figure 17. Postoperative X-ray of Proximal Shaft of Humerus Fixed with LCP

Figure 18. Preoperative X-ray of Fracture Proximal Humerus (Left)

Figure 19. Postoperative X-ray of Fracture Proximal Humerus (Left) Fixed with LCP

Figure 20. Preoperative X-ray of Comminuted Surgical Neck Humerus

Figure 21. Postoperative X-ray of Comminuted Surgical Neck Humerus Fixed with LCP

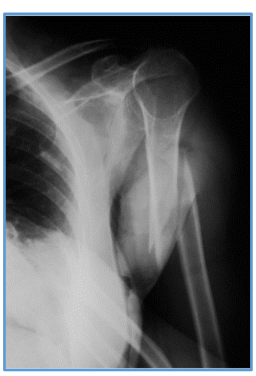

Figure 22. Preoperative X-ray of Oblique Fracture Shaft of Humerus

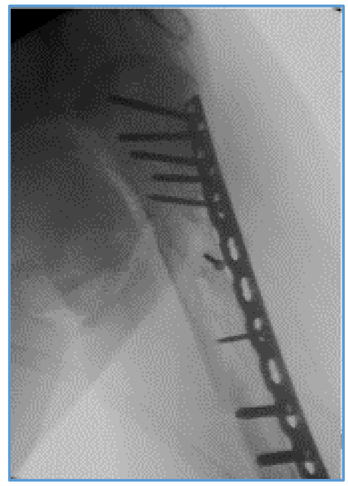

Figure 23. Postoperative X-ray of Oblique Fracture Shaft of Humerus Fixed with LCP

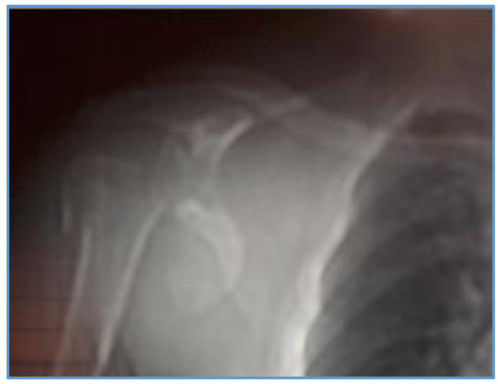

Figure 24. Preoperative X-ray of Comminuted Fracture Dislocation (R) Shoulder

Figure 25. Postoperative X-ray of Comminuted Fracture Dislocation (R) Shoulder

Figure 26. Schatzker Type 6 Fracture Tibial Condyle in a 56-Year-Old Male Patient Fixed with Clover Leaf 4.5 LCP 3 Months Postoperative Showing ROM Right Knee (Full Flexion)

Figure 27. Schatzker Type 6 Fracture Tibial Condyle in a 56-Year-Old Male Patient Fixed with Clover Leaf 4.5 LCP 3 Months Postoperative Showing ROM Right Knee (Full Extension)

Figure 28. Same Patient Showing Internal Rotation of Right Shoulder

Figure 29. Same Patient Showing External Rotation of Right Shoulder

RESULTS

We have high union rates in our series of 480 patients with osteoporotic fractures, but not without complications. We had union in all cases and no case of non-union. Union was seen in x-ray after 6 to 12 weeks (average 8 weeks) in fractures of upper limb and 10 to 16 weeks (average 11.2 weeks) in fractures of lower limb as evidenced by the appearance of bridging callus (or bridging of the cortex) and partial obliteration of the fracture site. The shortest time for union in our study was for distal metaphyseal fracture of radius (6 weeks). The union rate with locked compression plate on an average appeared to be 2-4 weeks earlier when compared to conventional fixations and longest was for shaft of femur (16 weeks). None of the fractures demonstrated absence of visible callus on plain radiographs. (16.67%) had minimal callus and (58.33%) had moderate callus whereas (25%) had abundant callus formation especially in those comminuted fractures.

The Complications Observed were as Follows:

- Superficial infection in 32 cases (6.66%)
- Deep infection 24 cases (5%)
- Delayed union 14 cases (2.91%)
- Mal-union in 12 cases (2.5%)

Post traumatic partial ankylosis of the adjacent joint is a regular finding in fractures nearer to the joint in most of the orthopaedic treatment modalities and is not in any way related to the mode of fixation in this study.

Thus, there were a total of 82 cases with different complications as noted above accounting for (17%) in total.

DISCUSSION

Most of the patients in this study were between the ages of 51 and 60 years (52.77%) and majority were males (67%).

Quality of reduction was associated with fracture type. Among the 192 cases of transverse fracture anatomical reduction could be obtained only in 76 cases (40%). Anatomical reduction was not attempted in comminuted fractures to preserve the biological properties.

Superficial infection was noted in 32 cases (6.66%), 21 in the tibia and 11 in the forearm which responded promptly to and antibiotic therapy and local cleansing and dressings. Deep infection developed in 24 patients (5%) all of which were open fractures, of which one case was a distal tibial metaphysis fracture where infection could be controlled only by plate and screw removal and external skeletal fixation. Other cases responded to antibiotics administrated parenterally followed by oral, based on culture and sensitivity results. There were 14 case of delayed union. Nonunion did not occur in any patient. Malunion, which remains common in other plating techniques occurred only in 12 patients in spite of the fact that contouring was restricted to avoid deformation of locking screw holes.[8,9] It remains a fact that malunion is not uncommon in conventional neutral as well as dynamic modes of plate fixation due to screw cut out, screw pull through and distraction at fracture site.

A specific problem which was noted in a few patients in our series was the implant site discomfort due to projecting part of the implants as in the case of proximal humerus where a T plate was used without contouring in the initial few case.[10] This problem was subsequently overcome by contouring where ever necessary. Yet another similar problem was the thickness of the plates which appeared to be more than the usual DCP and hence created placement problem in areas like subcutaneous locations as in distal tibia.

A deviation from standard LCP fixation was in the use of L and T plates in proximal humerus where it appeared sufficient for adequate fixation/stability instead of the standard proximal humeral plate. The advantage in this novelty was the marked reduction in cost of the implant. The standard PHILOS which is usually advised for proximal humerus is thick and heavy which is not only nonessential but is difficult for contouring and also may project through soft tissues making difficulty in wound closure and often causing discomfort to the patients usually. Another change in the method was that torque limiting instrument was not used as drilling of the screw hole as well as fixation were done using standard hand drill and hexagonal screw drivers respectively.

The mean operation time (from incision to complete wound closure) was 75 minutes (range, 45-100 minutes) which appears to be shorter compared to other plating techniques. Intra operative average blood loss was around 210 ml (range, 100-300 ml) and the average hospital stay was 8.4 days (range, 3-14 days) is comparable to other studies.

Partial use of the limb was possible by 14 days and full use of the limb by 42 days in fractures of proximal humerus though full ROM was still delayed and a strenuous physiotherapy program helped a lot in re-establishing good limb function. Implant site discomfort occurred where T/L plates were applied without contouring.[8,9] Problems like stress rising or stress fractures at the end of the plate did not occur. AVN of humerus was detected in one out of the four cases (25%) of 4-part fracture dislocation proximal humerus during the 6^{th} month of follow up but that patient had no symptom.

Humeral shaft fractures fixed with LCP could be mobilized without weight bearing by 21 days and full weight bearing by 60 days. Supracondylar fractures of humerus were mobilized by 4 weeks in these osteoporotic individuals and full mobilization was allowed by 90 days. Here again, joint stiffness took further 4-6 weeks for near normal function facilitated by good physiotherapy.

Both bone fractures of forearm were partly weight born by 45 days and fully by 90 days.

Of the 480 study patients 432 had good functional results, (90%) with nearly normal shoulder, elbow, wrist and knee function, without any noticeable pain, or any considerable stiffness and a full return to pre-injury activities and work, without pain at the final follow-up visit. 14 patients (3) patient required LCP removal due to infection and stabilization with external fixation

When compared with the Acta Orthopedica Belgium study reported in Acta Orthopaedica Belgium Vol 73-1-2007 some of the major complications like non-union, loosening of the implant breakage etc., did not at all occur in our series. Major problem identified in this series was infection which was of great magnitude only in 14 cases where implants had to be removed. Further infection is one area where the surgeon has restraints in effective control especially in government hospital set up in an economically downtrodden state.

CONCLUSION

Locked compression plating is an effective method of internal fixation in osteoporotic fractures. Average duration of healing is 9 weeks in upper limb and 12 weeks in lower limb. Complication rate was 17% if superficial infection, which was mild if not counted the rate falls to 10.34%. Post-operative rehabilitation is earlier. Locking of screws in the plate provides angular and axial stability. Hence LCP is more suitable in osteoporotic bones.[8,3,4]

Locked compression plating aids in the biological process of fracture healing by minimal surgical exposure since anatomical reduction is needed only in articular fractures, preservation of the periosteal blood supply and increased rate of bone healing. Complications are similar to all surgical procedures like: superficial infection -6.68%; deep infection -5%; delayed union -2.91%; mal-union-2.5%. Nonunion, screw back out (loosening of implant) breakage and re-fracture which are very common in earlier fixation systems were nil especially important in the setting of fixation of osteoporotic fractures. Thus, the functional outcome with LCP was very good in this study series. Full range of motion was observed in 86.11% by 3 months and in 97.22% by the end of 4 months. All the patients had near normal shoulder, elbow, wrist, knee and ankle function, without noticeable pain, and a full return to pre-injury activities. The limiting factor in declaring excellent result was because of the residual joint stiffness which occurred in cases of fracture dislocations of shoulder which in fact cannot be attributed to any inadequacy of the implant but to the associated musculotendinous injury which invariably occurs with such shoulder injuries.

REFERENCES

[1] Gardner MJ, Nork SE, Huber P, et al. Less rigid stable fracture fixation in osteoporotic bone using locked plates with near cortical slots. Injury 2010;41(6):652-656.

[2] Stromsoe K. Fracture fixation problems in osteoporosis. Injury 2004;35(2):107-113.

[3] Chakravarthy J, Bansal R, Cooper J. Locking plate osteosynthesis for Vancouver type B1 and type C periprosthetic fractures of femur: a report on 12 patients. Injury 2007;38(6):725-733.

[4] Zhang L, Miramini S, Mendis P, et al. Osteoporotic bone fracture healing under the locking compression plate system. ICCM 2015:1-5.

[5] Snow M, Thompson G, Turner PG. A mechanical comparison of the locking compression plate (LCP) and the low contact-dynamic compression plate (DCP) in an osteoporotic bone model. J Orthop Trauma 2008;22(2):121-125.

[6] Neuhaus V, King JD, Jupiter JB. Fixation of osteoporotic fractures in the upper limb with locking compression plate. Acta Chir Orthop Traumatol Čech 2012;79(5):404-410.

[7] Hauschild O, Ghanem N, Oberst M, et al. Evaluation of Singh index for assessment of osteoporosis using digital radiography. Eur J Radiol 2009;71(1):152-158.

[8] Luo CF. Locking compression plating: a new solution for fractures in rheumatoid patients. Modern Rheumatology 2005;15(3):169-172.

[9] Jayakumar P, Ring D. A pitfall in fixation of distal humeral fractures with pre-contoured locking compression plate. Arch Bone Jt Surg 2015;3(2):130-133.

[10] Sproul RC, Iyengar JJ, Devcic Z, et al. A systematic review of locking plate fixation of proximal humerus fractures. Injury 2011;42(4):408-413.