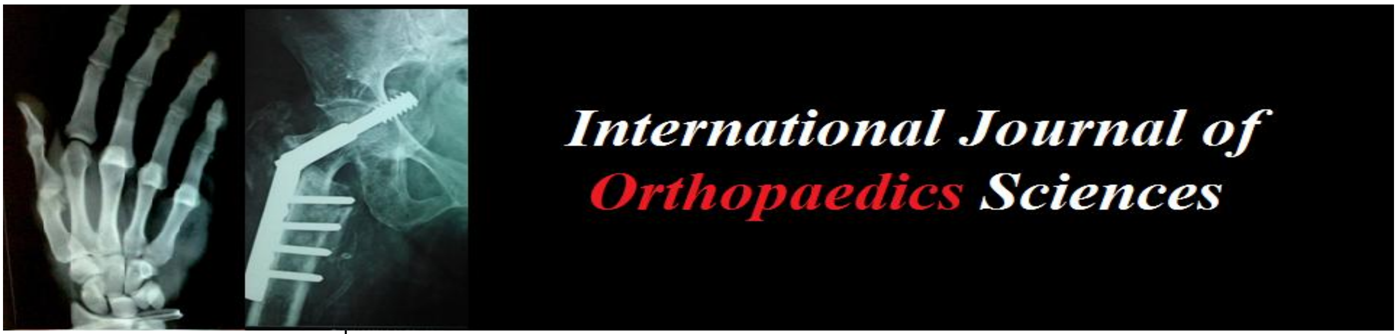

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Role of locking compression plate (LCP) in periarticular fractures knee

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Abstract
The number of hospitalized patients of peri articular fractures knee joint have been reported to be 32-35% of total trauma patients. The armamentaria of internal fixation devices available for these type of fractures are supracondylar nail dynamic condylar screw, T-butress plates, Dyanamic compression plates, Fixed angle blade plate, Zicker nail, Enders nail, Locking compression plate (LCP). The purpose of this study was to determine whether fixation by LCP is an effective method in the management of periarticular fractures around the knee joint. The average age in the present study was 40.96 years (ranging from 21 to 80 years). 22 cases were male and 3 cases were female. The average time to union was 20.32 weeks (range from 14 to 32 weeks). Based on functional criteria we recorded excellent results in 15 cases (60%), good in eight cases (32%), fair result in two cases (8%) with no poor result Based on anatomical criteria we recorded excellent results in nine cases (36%), good in 16 cases (64%) with no fair and poor result. The chief complications are infection, varus collapse, knee stiffness, articular N and secondary osteoarthrosis

Keywords: Locking compression plate, Fixation, Periarticular, Knee joint

Introduction
In the past few years number of road traffic accidents have alarmingly increased leading to an increase in high velocity trauma injuries. The number of hospitalized patients of periarticular fractures of knee joint have been reported to be 32-35% of total trauma patients [1]. Mechanism of injury in most of these fractures is thought to be axial loading with varus/Valgus or rotation forces. Injuries involving high energy periarticular fractures of knee joint (incliuding distal end femur and proximal tibia) are notoriously difficult to treat [2, 3] These injuries are often associated with extensive soft tissue and bony injury which results in a high complication rate and poor clinical outcome. The chief complications are infection, varus collapse, knee stiffness, articular malreduction and secondary osteoarthrosis. This study was carried out on twenty five patients in the Department of Orthopaedics, at a tertiary care hospital in Punjab.

For periarticular fractures around knee, aim of management is to achieve sound union in reasonable time with good range of knee joint movements. As multiple methods of internal fixation are available, it is customary to analyze each of the procedure and to reach of conclusion that at the end of day which procedure is most useful in a given situation, depending upon the type of fracture, site of fracture, quality of bone stock, comminution and whether injury is closed or open. Prior to 1970s, majority of fractures of lower third of femur were treated non-operatively by skeletal traction and then cast bracing [5]. Daniel Borgen, Sprague BL *et al* (1975) reported treatment of distal femoral fractures with early weight bearing. They treated these fractures non-operatively, but with early active knee motion and weight bearing made possible by the use of the cast-brace technique. Difficulties encountered during the treatment of distal femoral fractures are:

1. Angulatory deformity, either posterior angulation at the fracture site compromising knee motion or a valgus deformity disrupting overall leg alignment;
2. Knee joint incongruity and degenerative changes after intercondylar fractures;
3. Restricted active and passive knee motion due to quadriceps expansion injury and;
4. Delayed union and non-union [6].

The armamentaria of internal fixation devices available for these type of fractures now a days are supracondylar nail dynamic condylar screw, T-buttress plates, Dynamic compression plates, fixed angle blade plate, Zicker nail, Enders nail, Locking compression plate (LCP).Though properly performed internal fixation in a well-equipped centre, in hands of experienced surgeon gives good results but wide medullary canal, thin cortex & poor bone stock of this area makes internal fixation very-very difficult. Even nicely performed internal fixation, because of local characteristics of bone, often resulted in complications like screws pull out, breakage of screws/plate and then non-union / mal-union. Locking plates allow the surgeon to place a biomechanically stable internal fixator on the lateral side of distal femur and proximal tibia even through a limited surgical exposure. This technique will potentially allow for anatomic reduction and stable internal fixation while minimizing soft tissue problems often associated with the subcutaneous medial border.[4] Locked plate technology has evolved in an effort to overcome the limitations associated with conventional plating methods, primarily for improving fixation in osteopenic bone. The development of screw torque and plate-bone interface friction is unnecessary with locked plate designs, significantly decreasing the amount of soft tissue dissection required for implantation, thus preserving the periosteal blood supply, and facilitating the use of minimally invasive percutaneous bridging fixation techniques. The locked plate is a fixed-angle device because angular motion does not occur at the plate screw interface. The use of locked plate technology allows the orthopaedic surgeon to manage fractures with indirect reduction techniques while providing stable fracture fixation. The secure 'feel' of locked plates, ease of application, and the low incidence of complications noted in early clinical reports have contributed to the proliferation of this technology. Over past 30 years, implants and techniques have vastly improved. It is now recognised by most of the orthopaedic surgeons that periarticular fractures are best treated with reduction and stabilization. Anatomic reduction of articular surface, restoration of limb alignment, and early mobilization have been shown to be effective ways of managing these fractures.

Koval, Kenneth J.; Hoehl, James J *et al* (1997) in their *in vitro* study concluded that The locked buttress plate fixation for fractures of distal end femur provided significantly greater fixation stability than the standard plate both before and after cycling in axial loading. The locked buttress plate also proved significantly more stable in axial loading than the blade plate both before and after cycling [7]

Wilkens, Kenneth J MD; Curtiss, *et al* (2008) compared the mechanical stability of a conventional locking plate with that of a new polyaxial design of locking plate in comminuted supracondylar femur fractures and concluded that polyaxial locking screw mechanism provides a biomechanically sound fixation option for supracondylar femur fractures. The frictional locking mechanism allows maintenance of angular stability while affording the option of variable screw placement [8]. The purpose of this study was to determine whether fixation by LCP is an effective method in the management of periarticular fractures around the knee joint.

Material and Methods

This study was carried out on twenty five patients in the Department of Orthopeadics, at a tertiary care hospital in Punjab. Patients having periarticular fractures around knee joint i.e. fractures of distal part of femur and/or fractures of proximal part of tibia were included.

Patient with (a) Local or systemic infection (b) medically unfit (c) Previous osteotomy (d) Compromised vascularity (e) pathological fracture were excluded from the study. Informed consent was taken from all patients before including them in the study. The diagnostic workup of the patient included blood investigations and Roentgenogram in two planes of the affected limbs and three Dimension Computed Tomography of the affected limb if required. Fractures were classified according to AO classification. Soft tissue condition was looked into and if abrasions and blisters were present, surgery was delayed till skin had wrinkling sign positive. The procedure was done in patient with supine position under image intensifier control. Anterolateral approach was commonly used except in condition where medial condyle was severely comminuted or when there was posteromedial plateau fracture, where posteromedial approach was also used. Minimally invasive percutaneous osteosynthes (MIPO) technique was utilized in all cases. Reduction of fracture was achieved with help of traction or ligamentotaxis, or simple towel support under fragment or with help of K wire and pointed reduction forceps in split fracture. Reduction was checked by congruity of joint surfaces and if there was more than one fragment they were provisionally fixed with K-wires. In case of depressed fracture, articular fragment were elevated and reduced. The cavity thus created behind was filled with autologus bone graft. Two major fragments of condyles were then fixed with 6.5 mm cancellous lag screws. Using anatomic landmarks and fluoroscopy, the plate was mounted on intact or reconstructed condyles or plateau and temporarily fixed to bone with help of 2mm kirschner wires. Clinical examination and fluoroscopy were used to confirm that (a) screw projections in the proximal locking holes were parallel to the joint in the transverse plane and plate was oriented properly on the condyles. (b) Alignment of the plate to the shaft of the femur or the tibia was correct in both AP and Lat view. Bone defect left behind was filled with autogenous cancellous or corticocancellous bone graft. The wound was closed in layers and limb was supported with knee immobiliser till the patient was pain free. I/V antibiotics were continued for 3 days and then switched over to oral antibiotics. Physiotherapy was instituted from the second postoperative day in the form of quadriceps drill, knee and ankle mobilization exercises. Mobilization was started as soon as the pain permitted, first with non-weight bearing crutch support walking, followed by toe touch crutch support walking and then progressive weight bearing depending upon callus formation. In every follow up, the patients were assessed both clinically and radiologically for union and range of motion at knee. Malunion was defined as step off of the articular surface of 4mm on anterioposterior and lateral knee radiographs or malalignment of greater than 5^0 in any plane on full length X-rays.

Pre-Operative X-Rays (Tibia)

Post-Operative Xrays (Tibia)

Pre-Operative X-Rays (Femur)

Post-Operative Xrays (Femur)

Observations

a) Age

The average age was 40.96 years ranging from 21 to 80 years. The maximum number of cases 32% were in 21-30 years age group followed by 28% in 31-40 years age group while 1 case 4% was in 71-80 years age group (table I).

Table I: Age Distribution

Age group (years)	Number of cases	Percentage age (%)
21 – 30	08	32.0%
31 – 40	07	28.0%
41 – 50	04	16.0%
51 – 60	02	08.0%
61 – 70	03	12.0%
71- 80	01	04.0%
Total cases	25	100.0%

b) Sex

There were 22 males and three females.

c) Bone And Side Involved

Table II: Bone and Side Involvement

Bone involved	Side		Total
	Right	Left	
Femur	07	04	11
Tibia	08	06	14
Total	15	10	25

There were 11 cases of fractures of distal end of femur out which seven were with right sided and four were with left sided injury. There were 14 cases of fractures of proximal tibia out of which eight were with right sided injury and six were with left sided injury. In all there were 15 cases with right sided injury and 10 cases with left sided injury. The ratio of femur to tibia was 0.76:1 and overall ratio of right to left involvement was 1.5:1.

d) Mode Of Injury

Mode of injury was road traffic accident in 22 cases and fall from height in 03 cases.

e) Ao Classification Of Femur (Appendix I)

There were two cases of AO Type 33A fractures, three cases of AO Type 33B fractures and six cases of AO Type 33C fractures (Table III).

Table III: Distribution of Cases Involving Femur According To Ao Type

AO TYPE	Number of cases	Percentage%
33A	02	18.25%
33B	03	27.3%
33C	06	54.5%
TOTAL	11	100.0%

f) Ao Classification Of Tibia (Appendix II)

There were four cases of AO Type 41B fractures and 10 cases of AO Type 41C fractures (Table IV).

Table IV: Distribution of Cases According To Ao Type

AO type	Number of cases	%age
41A	00	00.0%
41B	04	28.6%
41C	10	71.4%
Total	14	100.0%

g) Injury Surgery Interval

The injury surgery interval ranged from 1to 24 days with an average interval between injury and surgery was 8.36 days. 60% of the cases were operated within 7 days of injury (table V).

Table V: Distribution of Cases According To Injury Surgery Interval

Time interval (days)	Number of cases	Percentage (%)
0-7	15	60
8-14	4	16
15-21	5	20
22-28	1	4
Total	25	100

h) Nature of Injury

Of 25 cases, there were 17 simple fracture and 08 open fractures (four cases were of open grade II, two case was of compound grade III A, two cases were of compound grade III

B and two cases were of compound grade III C According to Gustilo and Anderson Classification) (table VI).

Table VI: Distribution of Cases According To Nature of Injury

Type	Number of cases
Simple	17
Grade I	00
Grade II	04
Grade III A	02
Grade III B	02
Grade III C	00

i) Polytrauma

In 12 cases (48%) multiple injuries were present. All these patients were successfully resuscitated and operated as soon as their general condition stabilized.

j) Bone Grafting

Of 25 cases, only four cases had primary bone grafting, and in one patient secondary bone grafting done.

k) Post-Operative Hospital Stay

The period of hospitalization after surgery varied from 4 days to 36 days. The average hospital stay after surgery was 14.4 days.

l) Duration between Operation and Walking

The average duration in weeks of partial weight bearing was 8.16 weeks (range 6-14 weeks) while of full weight bearing was 19.2 weeks (range 12-28 weeks)**.**

m) Follow Up

The average follow up of patients is 10.88 months (range 7-21 months)

n) Time to Union

The mean time to union was 20.32 weeks (range 16-32 weeks). Maximum number of cases (68%) united at 20-22 weeks. The maximum time to union was 32 weeks in 1 case (table VI).

Table VI: Distribution of Cases According To Time Of Union

Radiological Union (weeks)	Number of Cases	Percentage (%)
14-16	08	32.0%
17-19	00	00.0%
20-22	09	36.0%
23-25	07	28.0%
26-28	00	00.0%
29-32	01	04.0%
Total	25	100.0%

o) Range Of Movements

The overall knee range of motion averaged 124 deg. (range30-150 deg.) at the latest follow up.

p) Complications

Out of the total 25 cases in the study, deep infection occurred in two cases (one case of grade IIIA and one case of grade VI). The postoperative malalignment occurred in a total of 12 cases (48%), although it was believed to be of clinical significance (>5degree) only in five cases (20%). In three cases there were coronal plane malreduction (valgus/varus) and in two patients there were sagittal plane malreduction. Only in one patient secondary loss of reduction occur with progressive varus angulation from 10 degree to 15 degree. The articular malreduction was seen in eight patients (32%) but it was of clinical significance (> 4mm step) in only two patients (8%). Stiffness and restriction of movements < 90 deg. was seen in two cases of grade VI. Delayed union occurred in one case of grade VI. and ACL and meniscus tear was found in one case of grade VI. Minor complications like extensor lag occurred in two cases (1 case of grade V and 1 case of grade VI).

Table VIII: Complications after Surgery

Complications	Grade II	Grade III	Grade IV	Grade V	Grade VI	Total	%
Deep infection		1			1	2	8
Superficial infection					0	0	0
Malunioin (angulation)	1				4	5	20
Malunion (depression)		1		1	0	2	8
Delayed Union					1	1	4
Non-union					0	0	0
Secondary Loss of reduction					0	0	0
Skin necrosis					0	0	0
Stiffness					2	2	8
Extensor lag				1	1	2	8
Sup tibiofibular subluxation		0				0	0
Acl and meniscal tear					1	1	4
Restriction of movement <90^0					2	2	8
Screw break					0	0	0

q) Functional and Anatomical Grading Score According To Rasmussens' Criteria (Appendix III).

The results obtained were analysed as excellent, good, fair and poor according to criteria given by Rasmussen (appendix III).Based on functional criteria we recorded excellent results in 15 cases (60%), good in eight cases (32%), fair result in two cases (8%) with no poor result (table IX).

Table IX: Distribution of Cases According To Functional Grade

Functional grade	Number of cases	Percentage
Excellent	15	60
Good	8	32
Fair	2	8
Poor	0	0
Total	25	100

Based on anatomical criteria we recorded excellent results in nine cases (36%), good in 16 cases (64%) with no fair and poor result (table X).

Table X: Distribution of Cases According To Anatomical Grade

Anatomical grading	Number of cases	Percentage (%)
Excellent	9	36
Good	16	64
Fair	0	0
Poor	0	0
Total	25	100

Discussion

In the present prospective study, 25 cases with periarticular fractures around knee joint were evaluated for results after fixation with locking compression plate. The average age in the present study was 40.96 years (ranging from 21 to 80 years). Horesh Z *et al* in their study found an average age to be 40.6 year (range from 30 to 70 years) [17]. Lee JA *et al* in a similar study found the average age to be 42 years ranging from 18 to 82 years [21]. This reflects that periarticular fractures around knee joint are common in young adult age group who are involved in outdoor activities. In our series 22 cases were male and 3 cases were female. The male to female ratio were 7.3:1. Blocker CP *et al* in their study on 64 patients had 34 male and 30 female with male to female ratio of 1.13:1. [16] The high male to female ratio in our study is probably because males are more involved in outdoor activities especially in our Indian scenario. In our study 15 cases had right sided injury and 10 cases had left sided injury. The ratio of right: left lower limb involvement was 1.5:1. Ryan *et al* noted right to left leg ratio of 1.4:1 [4] The more involvement of right leg in our study is probably because right side is the dominant side in most of the people and during road traffic accidents the brunt of injury falls on the most active limbs. We had maximum number of 22 cases due to RTA (88%), followed by fall from height 3 cases (12%). Lee JA *et al* in a similar study reported an incidence of 80% due to RTA, 11.4% due to fall from height, 5.8% due to blow and 2.8% due to shotgun injury [21]. This suggests that periarticular factures around knee joint commonly occurs due to high energy trauma. In our study out of 11 cases of fractures of distal end femur, two cases were Type 33A (18.2%), three were Type 33B (27.3%), six was Type 33C (54.5%), as per A.O classification. Out of 14 cases fractures of proximal tibia, four cases were of Type 41B and 10 cases were of Type 41C. Overall Type C alone accounts for 64% of all periarticular fractures around knee joint. Scotland T *et al* in their study on 29 tibial plateau fractures found Type C fractures account for 76% of cases [15]. This suggests that with modernization there has been a steep increase in high velocity trauma. In our study there were 17 simple fractures (68%) and eight open fractures (32%). Of open fractures according to Gustilo and Anderson classification three were of grade II (12%), one was grade III A (4%), two were grade III B (8%) and two were grade III C (8%). Ali *et al* in their study of 20 patients found five cases (25%) of open fractures, of which three cases (15%) were Gustilo grade IIIA and two cases (10%) were grade IIIB [9] Mikulak *et al* found 21% of open tibial plateau fractures in their study [11] This suggests that with increasing incidence of high velocity trauma, the cases of open fracture are on the rise. In our study, Polytrauma was present in 12 cases (48%) (four cases of head injury, two cases of chest injury-haemothorax, two cases of contralateral fractures of both bone leg, one case of fracture shaft of femur, one case of fracture pelvis, one case of supracondylar fracture of femur and one case of fracture both bone fore arm). Ryan *et al* reported that of 58 tibial plateau fracture patients, thirty nine (67%) suffered from polytrauma [4]. Blocker *et al* in their study of 64 patients of tibial plateau fractures found that 26 (40.6%) cases had associated polytrauma [16]. This suggests that high velocity trauma are often associated with multiple injuries. In our study the average interval between injury and surgery was 8.36 days (ranging from 1 to 24 days). 60% of cases (15 cases) were operated within first seven days of injury. Gosling T, Schandelmaier P, Mullar M in their similar study found average time to surgery was 7.5 day(range 0 to 28 days) [13] Lee JA *et al* found that all patients underwent operation with in a mean time of 12 days (range 1 to 30 days) [21]. The delay in surgery in our study could be because our institute is tertiary care centre where patients came after primary management outside. Secondly, at the time of presentation patients had swelling and abrasions around knee and operation were delayed till swelling subsided and abrasion healed and dried up. Thirdly, polytrauma patients were very unstable, therefore early fixation was not possible.In our study the average period of hospital stay after surgery was 14.4 days (ranging from 4 to 36 days). Sangwan SZ *et al* found the average duration of hospitalization were six days (ranging from 2 to 17 days) [19]. Thimmegowda M *et al* found average hospital stay was 10 days (ranging from 7 to 21 days) [20]. The long duration of hospitalization was due to fact that our institute is located in rural area, at the outskirts of city. Patients prefer to get their stitches removed before being discharged. In our study, the mean time of full weight bearing was 19.2 weeks (range from 12 to 32 weeks). Cole PA, *et al* found the mean time to allowance for full weight bearing was 12.6 weeks (ranging from 6 to 21 weeks) [18]. The delay in weight bearing in our study is because patient had associated injuries like fracture shaft of femur, fracture pelvis, fracture both bones leg. In our study the average time to union was 20.32 weeks (range from 14 to 32 weeks). Lee JA *et al* in their similar study found average time to healing of the 25 fractures as 4.2 months (range 3 to 7 months) [21] Ryan JK *et al* in their comparative study found that average time to union with locking plating was six months (range 3 to 14 months) versus seven months (range from 3 to 15 months) in external fixation group [4]. This suggests that periarticular fractures (around knee joint) with metaphyseal extension take longer with other methods of fixations when campared with locking plate fixation. In our study the overall range of motion at knee joint averaged 124 deg. (range 30-150 deg). Stannard JP *et al* [14] in their similar study measured average range of motion of 127 deg. (range 90-145deg). Lee JA *et al* [21] in their similar study found overall range of motion averaged 105 degree (range 0-135 deg). Cole PA *et al* in their study found mean range of final knee motion of 122 d eg. [18] Ryan JK *et al* in their comparative study found that the average knee flexion in locked plating patients was 109 deg. (range 75-150 deg) versus 104 deg. in external fixation patients.[4] Good range of motion (average 124 deg) at knee can be attributed to early knee motion. Open reduction increases fibrosis and thus decreases subsequent range of motion, but this difficulty is minimally seen with less invasive methods like LCP fixation. In our study, primary bone graft was used in 20% of cases in depressed tibial plateau fractures and in severly comminuted fractures of distal end femur. Gosling T, Schandelmaier P, Muller M in their study used primary bone grafting in 19% of patients [13]. The mechanical principle of plates with locking head screws is similar to external fixation. For external fixation, non union rates of 0-4% without bone grafting have been reported [9, 10] This suggests that routine primary bone grafting of the metaphyseal defect is not necessary with locking head screw plates. To achieve union in one case of fracture of distal end of femur (which was associated with ipsilateral fracture of shaft of femur and was fixed using single long locking compression plate), secondary bone grafting had to be done at shaft fracture site. This suggests that in such cases with segmental fractures, primary bone grafting should be done at shaft fracture site. In our series, deep infection occurred in two cases (8%), both were cases of open fractures (according to Gustillo Anderson classification, one case was of grade III and one case was of grade VI). Both of them were treated with irrigation and debridement followed by antibiotic therapy and infection resolved with four weeks" of antibiotic treatment. These finding are supported by studies by Egol *et al* [12] with no reported infection, Stannard *et al* with a 5.9% rate of infection [14], Cole *et al* with an infection rate of 4% [18] Ryan *et al* [4] with an infection rate of 7% in locking group [4] and 13% in external fixator group and Lee *et al* with deep infection of 8%. [79] The infection rate seen in their study (8%) could be expected as tibial plateau fractures are high energy injuries with high rate of soft tissue complications. The less incidence of infection in locking plate using minimal invasive technique is due to aseptic technique, minimal soft tissue handling, small invasion and minimal duration of surgery. This gives this method an edge over open methods where extensive exposure is made and a lot of hardware is used especially in bicondylar fractures. In our study, the postoperative malalignment occurred in a total of 12 cases (48%), although it was believed to be of clinical significance (i.e>5 degree) only in 5 cases (20%). In three cases, there were coronal plane malreduction (valgus/varus) and in two patients there were sagittal plane malreduction. The articular malreduction was seen in eight patients (32%) but it was of clinical significance (i.e >4mm of step) in only two patients (8%). Lee *et al* in a similar study noted malalignment of eight fractures (32%) postoperatively, in one case fracture healed in six degree of varus and in seven cases fractures had an articular angulation (in the sagittal plane) of six degree. There was no case of secondary loss of reduction [21]. Cole *et al* cited 3.9% of incidence of malalignment. Ryan *et al* [4] in their comparative study reported malunion (angulation and articular depression) in 14% of cases in locking group compared to 43% in cases of external fixator group [18].

Conclusions

It is concluded that Locking Compression Plate offers a good treatment option for periarticular fractures around knee joint (i.e distal end of femur and proximal end of tibia) without any need for additional medial stabilization, as it provides improved healing rate, restoration of articular surface, better biomechanical stability, increased range of motion, decreased complication rate, decreased incidence of re-operation, early rehabilitation. Long term follow up and prospective randomized study would certainly add to validity of these conclusions.

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