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Analysis of Broken interlocking screws after intramedullary nailing of long bone fractures.

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Abstract- Interlocking nailing potentially is complicated by failure of the hardware around the nail aperture for distal metaphyseal fractures, communited fractures, fractures with delayed union, and fractures with small nails.

For many reasons, broken screws occur most often after static interlocking of femur & tibia. Fatigue failure causes bending & breakage of the screws.

The purpose of this study is to find the causes for breakage of screws after analyzing the fracture type, pattern, level & type of nail & screws used.

386 cases of reamed interlocking nailing of tibia & femur done from Nov 2006 to June 2008 at our institution. 24 cases with interlocking screw breakage were studied. 21 cases were males & 3 cases were females with mean age group of 36.58yrsyrs. 14 cases were tibia & 10 cases were femoral interlocking.

Average time of screw breakage was 13.18 weeks. Delayed union was seen in 5 cases, nonunion in 2 cases, 13 cases fracture was uniting well, two cases significant gap was seen immediate postoperatively & in 2 cases fracture had united prior to screw breakage. Dynamisation was done in 3 cases before screw breakage & bone grafting in 2 cases. Distal locking was done with 2 screws in 3 cases. Screw near to fracture site was broken in 15 cases, one case distal one of distal screws, 2 cases both proximal & distal screws were broken. One case both distal screws were broken. 4.5 mm screws of two different companies X & Y were used. In 22 cases X screws have broken & in 2 cases Y screws have broken.

Index Terms- broken screws, interlocking nail, interlocking screws.

I. Introduction

Interlocking nailing with the advantages of minimal tissue injury & stable fracture fixation has been well accepted for treatment of fracture shaft tibia & femur.[1,2,3] However , interlocking nailing is potentially complicated by failure of the hardware around the nail aperture, especially for distal metaphyseal fractures, communited fractures, fracture with delayed union, & fractures fixed with small nails.[3,4]

Implant failure may be single load yielding or more commonly cyclic load fatigue fracture & is closely related to the implant design.[5] Fatigue failure causes bending & breakage of screws.[6] This seemingly minor problem can confound the treatment of fractures & may necessitate further reconstructive surgery, as removal of broken screws can be difficult. In this study we tried to find the causes for breakage of screws after analyzing the fracture type, pattern, level & type of nail & screws used.

II. Materials & Methods

Three hundred & eighty six cases of interlocking nailing of femur & tibial fractures were done between Nov 2006 – June 2008 at Sparsh hospital, Bangalore. Twenty four cases with screw breakage after reamed static interlocking were analyzed retrospectively during this period. Two of the cases were operated elsewhere. 14 cases were tibial & 10 cases were femoral IL nailing. Three cases were type 3A open, 7 cases were type2 open fractures. Average age of the cases was 36.58yrs (19-70yrs). 21 cases were males & 3 were females. Average weight of them was 64 kg (50-78kg). Company X screws were used in 22 cases & company Y screws in 2 cases (fig.1). In all the cases 4.5 mm screws were used except for proximal locking in femur where 6.5mm screws were used (table 1).

Preoperative, immediate postoperative & follow-up x-rays along with weight bearing status were analyzed.

III. Results

Average time for screw breakage was 13.18 weeks (1-33weeks). This was the period when broken screws were identified for the first time during the follow up. Delayed union was seen in 5 cases (4 tibial & 1 femoral IL nail). Two cases of tibial IL nail were associated with nonunion. Fracture had united before the screw breakage in 2 cases of tibial IL nail.

Out of 10 femoral IL nails, 5 cases were of Winquist type 4, 2 were type3, 2 were type 2 & 1 was a segmental fracture (fig.2). Single distal locking screws were used in 7 of these cases (four type 4, two type 3 & one type 2) (fig.3 & 4). In one case two distal screws were used, both of them had broken. In 2 out of 3 cases D1 (proximal of distal locking screws) screw was broken (table 2). The screws were broken in the centre in 9 cases, & at the tip with backout in 1 case. In 2 of the cases 10 size nail was used & in 8 cases 11 size nail was used. The location of the distal locking screw was 2cm from fracture site in 2 cases & in 1 case it was 1cm with 2mm gap at the fracture site. In one case screw was not perpendicular to the nail axis & in two cases medial displacement of the nail was noticed at the distal end. Though all of them were advised non weight bearing mobilization, early weight bearing was done in 8 of them. In 1 case bone grafting was done at 4th week, in another case broken screw was removed & relocked with bone grafting. In one case broken single locking screw was removed & relocked with 2 screws at 1 week. Four cases healed well, 3 showed signs of union with good amount of callus till the follow up.

Out of 14 tibial IL nails, two distal locking screws were used in 3 cases. D1 breakage seen in 1 case, D2 (distal of two distal locking srews) breakage in 1 case & both D1 & D2 broken in 1 case (table 2). Isolated proximal screw breakage was seen in 3 cases out of which one had both P1 (proximal of two proximal locking screw) & P2(distal of two proximal locking screw) were broken. Both proximal & distal screws were broken in 3 cases. In 8 cases 10 size nail was used & 11 size nail used in 6 cases. All the screws were broken in the centre. In two of them fracture was fixed in valgus position out of which one was communited distal ¼ th fracture (fig.5). Early full weight bearing was done in 4 cases. In 4 cases proximal dynamisation was done before screw breakage. In one case of nonunion exchange nailing with bone grafting was done. Another case of nonunion lost for follow up.

Metal analysis:

Both X & Y screws were sent for chemical analysis (table 3). X screws was made of 316 stainless steel with more carbon content. Y screws had relatively less carbon content & more of manganese, nickel.

IV. Discussion

For many reasons, broken screws occur most often after static interlocking nailing of tibia & femur. Under loading, the failure pattern of locked nails determined by their design[5]. Smaller diameter nails require smaller diameter interlocking screws, increasing likelihood of fatigue failure[6]. This is proved by the fact that very rarely proximal femur locking screws break, which is of 6.5mm size. There has been tradeoff between the strength of the screw & strength of the nail around nail aperture[7]. Increasing the screw strength by increasing the screw diameter necessitates a larger nail aperture & may jeopardize the strength of the nail. Yielding consistently occurs at the middle of the screw, & yielding strength was closely related to the inner diameter of the screw. However the material properties & the degree of cold working also might affect the yielding strength of screws[5]. Mechanically, the fatigue strength is affected by the inner diameter of the screws, the material, the manufacturing process, & the thread profile, which determine the magnitude of the stress concentration effect[7].

In our study, chemical analysis report (table 3) showed that X screws had strength less than the standard 316L stainless steel screws used commonly. However the mechanical strength of the screws has not been evaluated using the three point bending test, which is one of the potential weaknesses in our study.

Prior to screw breakage, significant stress is placed not only at the junction of the nail & the screw, but also at the bone-screw interface. As the fatigue failure occurs at the distal screws, nail advances distally towards the ankle or knee joint, sagging the screw into what is called "Hammock" sign[6]. In our study it was also noticed that screws have broken after dynamisation in 3 cases of tibial interlocking (fig.6).

The amount of communition or load bearing of the fracture ends, the number of distal locking screws used, the distance between the fracture site & the nearest distal locking screw, and the nature of contact between the nail & bone affect the transfer of load between the bone & the nail, & can cause significant stress within the interlocking screws[8]. The stress increases as the distance between the screw & the fracture site decreases[9]. It may be safe to use an antegrade IL nailing when fracture lies more than 3cm away from the site of proximal of two distal locking screws in femoral shaft fractures[8]. In our study, 3 cases of femur IL nailing, distal locking screws were close to the fracture site due to shorter size nail.

Brumback et al[10] have published the results of biomechanical & clinical study on the efficiency & safety of early weight bearing after statically locked nailing in Winquist type 3& 4 femoral fractures. High endurance values for 12mm nail with 2 distal locking screws was seen & all of them healed without any hardware failure after early weight bearing. Two distal locking screws are necessary for early weight bearing especially for type 3 & 4 fractures[11]. In our study single screws were used for distal locking in 7 out of 8 type 3 & 4 fractures which have broken.

In spite of screw breakage, most of the femoral fractures showed good signs of healing, whereas in tibial fractures more number of delayed union was seen. Reason for this could be good soft tissue coverage in femur when compared to tibia. Also smaller diameter nail was used in 8 of 14 cases of tibial IL nail.

The potential weakness in our study is, less number of study population & lack of comparative results when two different types of screws were used. This was mainly because of loss of follow up of all the cases of IL nailing done during the period.

V. Conclusion

From our study we conclude that hardware failure after interlocking nailing of femur & tibia can be prevented by using appropriate size of nail with good cortical contact. Two distal locking screws must be used in Winquist type 3 & 4 fractures. The screw must be inserted properly at appropriate location from fracture site. Protected weight bearing should be done in severely communited fractures. Better quality screw with good strength must be used. Dynamisation may not prevent from screw breakage.

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X screw **Yscrew**

Figure.1

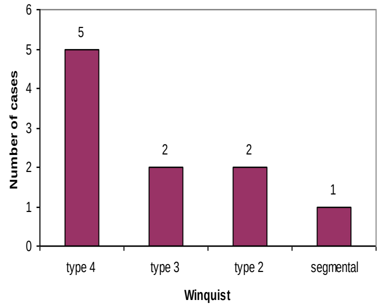

Figure.3

Figure.4

Figure.5

Figure.6

Table 1: Implants used

	Femur	Tibia
Nail size 10mm	2	8
Nail size 11mm	8	6
One distal screw	7	11
Two distal screw	3	3
Premature weight bearing	7	6

Table 2: Results

Broken screw	Femur	Tibia
D1	2	1
D2		1
D1&D2	1	1
Proximal		3
Proximal & Distal		3

Table 3: Chemical analysis of locking screws

	X screw	Y screw
C%	0.059	0.067
Mn%	1.526	> 2.040
Si%	0.515	0.642
P%	0.028	0.014
S%	0.008	0.009
Cr%	17.268	20.183
Ni%	10.012	10.054
Mo%	2.026	2.347

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