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Safe corridor for fibular transfixation wire in relation to common peroneal nerve: A cadaveric analysis

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ABSTRACT

Background: Peroneal nerve impalement is a recognized complication of percutaneous placement of fibular transfixation wires by palpatory method after increase use of ilizarov technique in treatment of Tibial fractures, deformity correction and limb lengthening. The purpose of this study was to identify the relationship between the Common Peroneal Nerve (CPN) and the palpable landmark, fibular head for insertion of proximal fibular transfixation wire, safe zones in proximal tibia and percentage of fibula where nerve crosses the neck.

Methods: Standard 1.8-mm Ilizarov k- wires were inserted in the fibula head of fresh 10 un-embalmed cadaveric knees. Wires were inserted percutaneously to the fibula head by palpatory technique. The course of common peroneal nerve was dissected. Distances from wire entry point to the course of the common peroneal nerve were measured post-wire insertion.

Results: The mean distance of the common peroneal nerve from the anterior aspect of the broadest point of the fibular head was 25.10 ± 4.39 mm (range 16–35 mm). Common peroneal nerve was seen to cross the neck of fibula at a mean distance of 32.3 ± 8.53 mm (range 20–50 mm). Wire placement was found to be on average, 46% of the maximal AP diameter of the fibula head and 44% of the distance from tip of fibula to the point of nerve crossing fibula neck.

Conclusion: We recommend Proximal fibula transfixation wires are safer to pass with in 2 cm from the tip of the styloid process of the fibula, Anterior half of the head of fibula, <8% of total fibular length, Ventral half of the anterior compartment to avoid injury to peroneal fan. The palpable landmark of fibula is a misinterpretation; it is just the prominent subcutaneous portion of fibula and not the styloid process of fibula which on dissection was located much posterior. Better to take fluoroscopic guidance in difficult cases where palpation of head of fibula is difficult.

1. Introduction

In the advent of extensive use of Ilizarov fixator in tibia for various conditions including acute trauma, deformity corrections and leg lengthening, the fibula has to be transfixed at both ends to prevent any subluxation of proximal tibio-fibular joint.Importance of fibular transfixation wire is important in Ilizarov fixation of Comminuted lateral lateral condyle of tibia fracture with intact fibula (Fig. 1) where tensioning this olive wire, the fibular head is compressed onto the lateral condyle giving a buttress effect.[1–4]

Proximal wires are placed from the lateral side usually by palpation techniques.[5] A thorough knowledge of the anatomy of the CPN and its branches is essential for fibular transfixation wire placement during ilizarov fixator application. In the leg, the CPN courses superficial to the lateral surface of the fibula and approximately 1–2 cm distal to the fibular head and passes into the fibular tunnel [6,7]. The motor division of common peroneal nerve supplies the muscles of dorsiflexion of the foot and extension of the toes, and injury to the nerve will lead to foot drop. Gerdy's tubercle, the fibular head, and the long head of the biceps femoris (LHBF) tendon are important landmarks in determining the location of the CPN in the lateral aspect of the knee.[8–11] The purpose of this study was to identify the relationship between the CPN and an easily palpable landmark, the fibular head, measure the distance of the nerve from the wire inserted into the proximal fibula percutaneously and to identify the safe corridor for fibular transfixation wire placement through proximal tibio femoral joint and to find the proportion of fibula where the nerve crosses it.

2. Materials and methods

Ten fresh cadavers were obtained un-embalmed allowing dissection of the nerve with no concern for the condition of the

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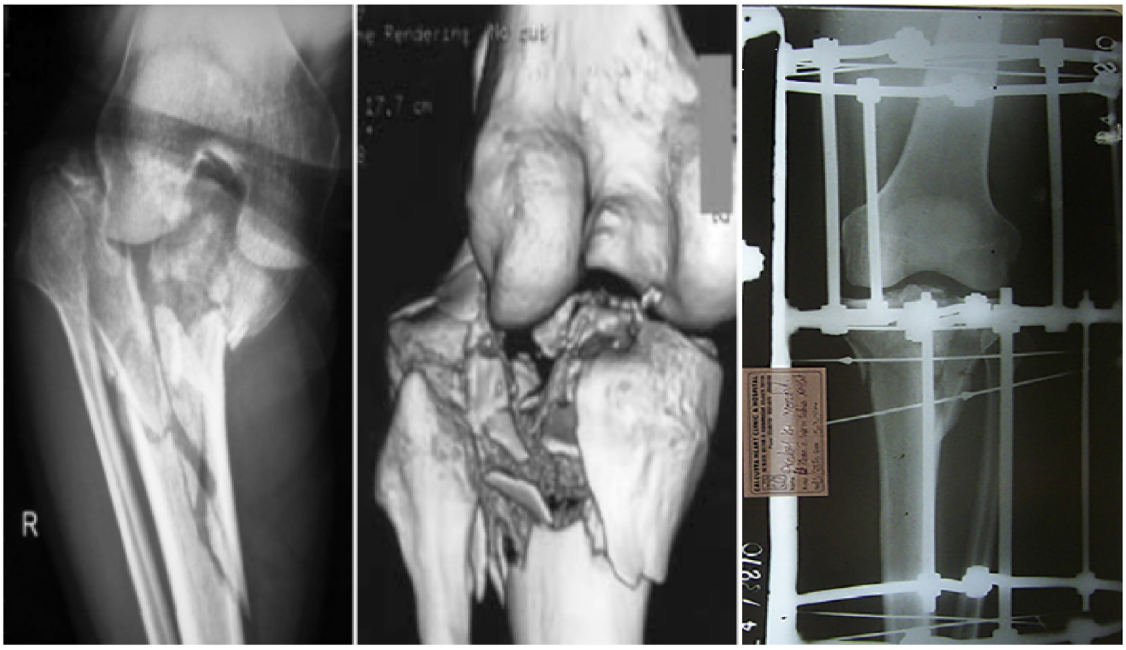


Fig. 1. The Xray and CT images showing the Comminuted tibial plateau fracture with intact fibula, buttressing effect of fibula with fibular transfixation wire.

soft tissues altering the measurements. The cadavers were mostly young adults with good soft tissue cover over the knee joint with no evidence of injuries. The knees were positioned in extension and neutral rotation. Standard 1.8-mm Ilizarov k-wires were placed to transfix the fibula head to the proximal tibia. The wires were inserted under the supervision of the main author who is experienced with the insertion of such wires in Ilizarov frame surgery. The surface markings of the fibula head were palpated and the wire was inserted aiming to be in the centre of the head in both planes as shown in Figs. 2 and 3. The whole length of the fibula was measured. Following insertion, a lateral dissection centred on the fibula was carried out. The nerve was identified proximally as it passes posterior to the lateral head of gastrocnemius and gentle dissection was done along its course towards the fibula head. Measurements were taken with normal measuring tape and with needles placed at respective points as shown in Figs. 4 and 5.

The schematic representation of the measurements and calculations are described in Fig. 6.

3. Results

The mean diameter of the fibula at its widest point was 20.6 ± 2.35 mm (range 17–26 mm). The wire was inserted on average 9.45 ± 1.47 mm from the anterior aspect of the fibula

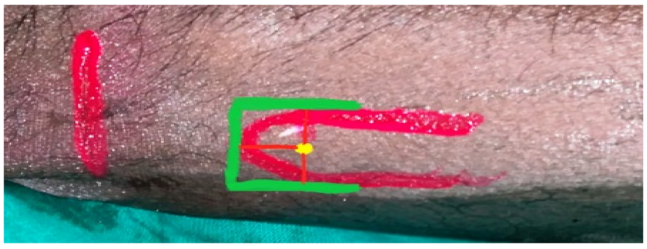


Fig. 2. The fibular head and joint line marked with red colour paint before wire insertion, perpendicular lines drawn tangential to superior, anterior and inferior palpable borders and its intersection point is marked as centre for wire insertion.

Fig. 3. 1.8 mm k wire passing in to center of fibular head after palpation.

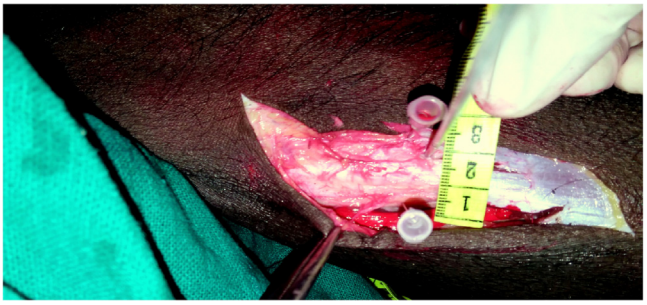


Fig. 4. The two needles marks the AP dimensions of broadest part of head of fibula.

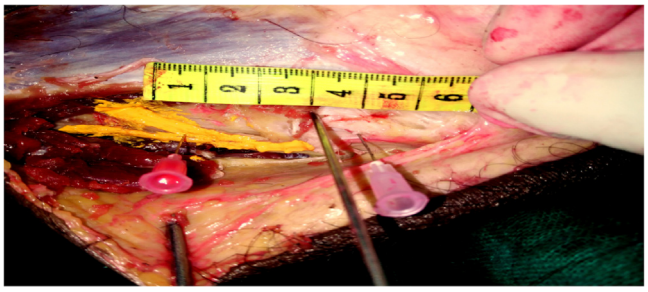
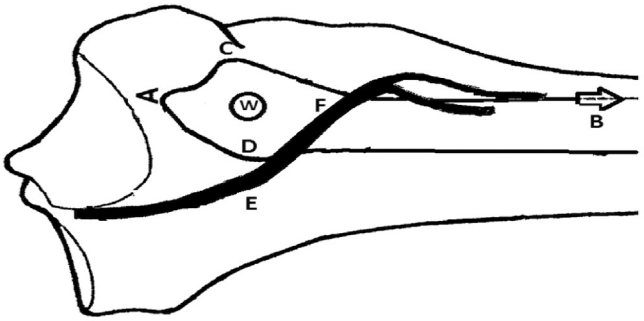


Fig. 5. The needle on right shows tip of styloid process of fibula and on the left shows the point where nerve crosses fibula, CPN is painted yellow in this picture.



AB – Whole length of fibula	**CW/CE – Wire to nerve ratio (%)**
CD – AP dimension of Fibula at its broadest Point	
CE – Anterior most point of fibula to CPN	**AW/AF – Ratio distance wire to nerve from tip (%)**
CW – Anterior most point of fibula to wire	
AW – Tip of Fibular styloid to wire	**AF/AB – Ratio of nerve from tip to whole length of**
AF – Tip of fibular styloid to crossing point of CPN	**Fibula**

Fig. 6. Schematic representation of measurements and calculations.

(range 7–12 mm). The mean distance of the common peroneal nerve from the anterior aspect of the broadest point of the fibular head was 25.10 ± 4.39 mm (range 16–35 mm). From these measurements, a ratio was calculated, demonstrating that, on average, the wire was inserted 46% of the way back from the anterior edge of the fibula (range 35–55%) in relation to its maximal AP diameter. Wires were on average 38.4% of the distance from the anterior aspect of the fibula to the nerve lying posterior (range 27–50%). The values are summarized in Table 1.

The relationship of the nerve from the posterior aspect of the fibula, in some cadavers with bulky muscles the nerve was long way posterior and in some cadavers the nerve was in close proximity to the posterior surface of fibula as shown in Figs. 7 and 8. The distance from the tip of the styloid process of the fibula to the point of wire insertion was on average of 13.25 ± 1.94 mm (range 10–27 mm). The distance from the tip of styloid process of the fibula to the nerve where it winds around the neck was 32.3 ± 8.53 mm (range 20–50 mm). Calculating these results as a ratio, the wire was on average inserted 44% of the distance from the fibula styloid to the point of nerve crossing fibula neck (range 24–75%) (Table 2).

The mean fibular length was 36.1 ± 1.2 cm and the distance where it winds to anterior was found 3.2 ± 0.8 cm from the apex of the head of the fibula. The percentage of fibular length where it crosses anteriorly was found to be nearly 9% of its whole length.

The clinical centre of head of fibula is as shown in Fig. 9, but upon dissection it s observed that the actual center is even posterior to clinical center as shown in Fig. 10. The Quadrant diagram (Fig. 11) shows the position of nerves in our study and CPN

Table 1
Average measurements in mm of the diameter of the fibula head at its maximum antero-posterior width, distances from the anterior aspect of the fibula to the wire, and to the nerve lying posterior.

Specimen	AP fibular head diameter (mm)	Anterior fibula to wire (mm)	Anterior fibula to nerve (mm)	Wire to nerve ratio (%)	Fib diameter/ Wire ratio (%)
1	21	9	25	36	42.86
2	21	8	24	33.33	38.1
3	20	7	25	28	35
4	20	8	27	29.63	40
5	17	7	16	43.75	41.18
6	17	8	18	44.45	47.06
7	20	10	24	41.67	50
8	20	10	26	38.46	50
9	20	11	23	47.82	55
10	23	8	25	32	34.78
11	19	9	33	27.27	47.37
12	20	10	35	28.57	50
13	20	9	22	40.91	45
14	20	11	22	50	55
15	19	10	23	43.78	52.63
16	19	10	23	43.78	52.63
17	26	12	28	42.86	46.15
18	22	10	26	38.46	45.45
19	22	10	28	35.71	45.45
20	26	12	29	41.38	46.15
Mean	**20.6**	**9.45**	**25.1**	**38.3915**	**45.9905**
Min	**17**	**7**	**16**	**27.27**	**34.78**
Max	**26**	**12**	**35**	**50**	**55**
SD	**2.34857179**	**1.46808145**	**4.38778208**	**6.79558934**	**5.986620587**

Fig. 7. The CPN (yellow colour painted) is far posterior to posterior surface of fibula separated by the part of lateral belly of gastrocnimeus.

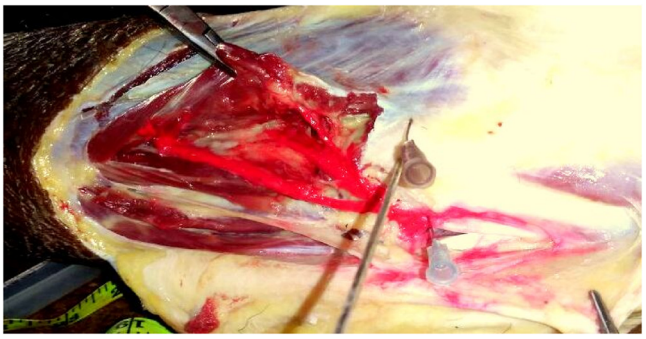


Fig. 8. The Close proximity of the nerve to posterior aspect of fibula as denoted by needle.

was mostly seen in Postero superior and Postero inferior quadrant, the wires are in safer zone if it is passed through anterior 60% of head of fibula by palpatory techniques.

4. Discussion

Our study mainly demonstrates the relationship of the CPN and an easily palpable landmark, the fibular head and its proximity to k wire, level and percentage of fibula where nerve winds around its neck when compared to whole length of fibula in our study.

The Fibres of the common peroneal Nerve consistently formed three major divisions (Ant. Recurrent, superficial and deep) as they wrap around the fibular neck.[8,12,13] Most of our specimens demonstrated the broad fanning of fibres as noted in Fig. 12.

There is no universal recommendation for placement of proximal tibia wires, some authors advise to apply anterior to fibular head in most conditions and some prefer to apply through the head of fibula for better stability as shown in Fig. 13. The common peroneal nerve is in close proximity during trans fibular wire fixation as shown in Fig. 13b. Here comes the importance of thorough knowledge of common peroneal nerve during insertion of fibular transfixation wire.[14–16]

We have found that the distance from the tip of the styloid process of the fibula to the nerve as it winds around the neck was 32.3 mm (range 20–50 mm). This finding was similar quoted by the following authors as mentioned in Table 3.This finding concurs with Rupp et al.[17] and Dearden et al.[5] and same as Ryan et al.[6]. In case small metaphyseal fragments, need of drop wires are essential. It is advised to place the drop wires within 2 cm of head of fibula to prevent iatrogenic nerve injury.

Table 2
Average measurements of the distance from the tip of the fibula head to the wire and to the nerve as it crosses the fibula neck and the full length of fibula and percentage ratio of the distance of the wire from the tip of the fibula to the nerve and ratio of fibula where nerve crosses the neck.

Specimen	Tip fibula to wire (mm)	Tip fibula to nerve (mm)	Full length of fibula (mm)	Ratio distance wire to nerve from tip fibula (%)	Ratio of fibula where nerve crosses the neck (%)
1	12	27	350	44.45	7.71
2	14	28	350	50	8
3	15	32	380	46.88	8.42
4	17	34	380	53.13	8.95
5	15	20	370	75	5.41
6	14	21	370	66.67	5.68
7	10	30	380	33.34	7.89
8	10	38	380	26.32	10
9	15	22	360	68.18	6.11
10	12	24	360	50	6.67
11	12	50	360	24	13.89
12	15	45	360	33.33	12.5
13	12	50	350	24	14.29
14	10	30	350	33.33	8.57
15	14	35	340	40	10.3
16	15	32	340	46.87	9.41
17	14	36	360	38.89	10
18	13	34	360	38.24	9.45
19	14	28	360	50	7.78
20	12	30	360	40	8.33
Mean	**13.25**	**32.3**	**361**	**44.1315**	**8.968**
Min	**10**	**20**	**340**	**24**	**5.41**
Max	**17**	**50**	**380**	**75**	**14.29**
SD	**1.943275**	**8.529207**	**12.52366**	**14.16547**	**2.430455**

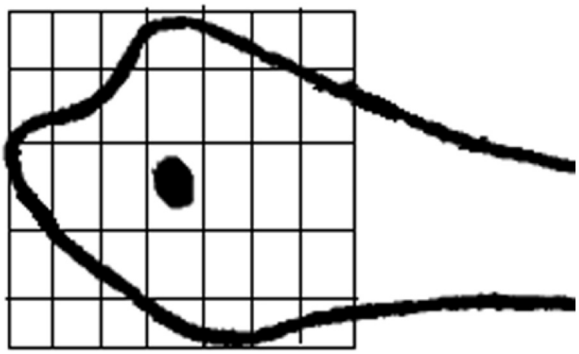


Fig. 9. Palpatory center of head of fibula.

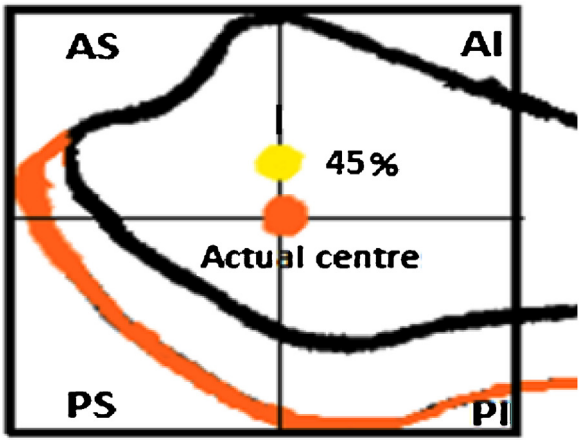


Fig. 10. Actual center of fibular head was posterior as compared to palpatory center. Black border shows the palpatory center and red border shows the actual border of fibula.

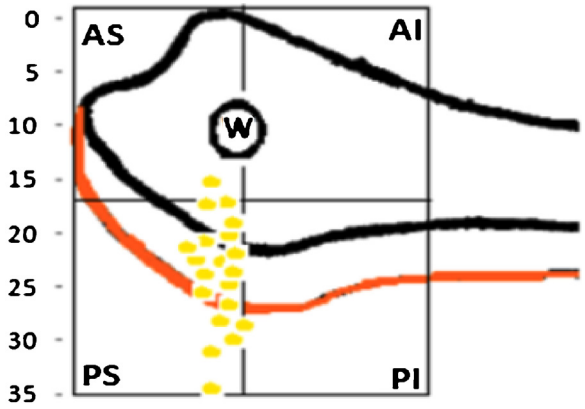


Fig. 11. Quadrant diagram shows the Postero superior and Postero inferior locations of nerves in our study. The lowest was 14 mm from anteriormost part of head of fibula.

Fig. 12. Broad fanning of CPN with its branches shown in this picture.

The mean diameter of the fibular head at it broadest diameter in the AP plane was found to be 20.6 mm (range 17–26 mm) which was similar to 22.34 mm similar to Dearden et al.[5] The wires in our series were seen to be inserted, on average, 9.45 mm from the anterior aspect of the fibula at its broadest point which was bit lower than Dearden et al.[5]

From these measurements, a ratio was calculated and demonstrates that the wire was on average inserted in the center or 46% of total anterior-to posterior diameter at its widest point (range 35–55 %) when using a landmark palpation technique. So

Table 3
Comparison of distance of nerve from tip of styloid process of fibula with various studies.

Year of study	Author	No. of Specimens	Tip of Styloid to Nerve (mm)
1992	Stitgen et al.[4]	20	20.0
1994	Rupp et al.[10]	10	35.0
2003	Ryan et al.[2]	30	32.0
2015	Dearden et al.[1]	10	34.8
2015	Hildebrand et al.[11]	16	21.9
2017	**Our study**	**20**	**32.3**

the center of fibula is just posterior when compared to palpatory center as discussed earlier.

The distance of the nerve behind the fibula at the widest AP diameter was 25 mm (range 16–35 mm) from the anterior aspect of the fibula which was similar to 24.5 mm as reported by Dearden et al.[5]

In nine of twenty specimens, the nerve was touching and lying in the posterior border of fibula at its maximum AP diameter. If wire is inserted in posterior aspect of fibula there is a risk of injury to CPN. Calculating a ratio, the wires inserted in this study were 38% of the distance from the anterior aspect of the fibula to the nerve lying posterior (Range 27–50%).

After measurements had been taken, the fibula head was dissected in all the specimens and it was found to be extending` more proximal and posterior when compared with palpation before dissection. By using a landmark palpation technique, if the wire was inserted too distally and too posterior there is higher chance of injury to the common peroneal nerve.

The mean (SD) fibular length was 36.1 ± 1.2 cm (Range 34–38 cm) which was similar to findings with Ryan et al.[6] who reported to be 35.7 ± 2.1 cm. The percentage of Fibular length where Common peroneal nerve crossed the fibula anteriorly was about 9% in our study which was 9.7% as stated by Ryan et al[6]. This is significant in case of children's or dwarf individuals whose fibula length is $\leq$20 cm.

Buttress effect to lateral condyle, better purchase in comminuted fragments of tibia through fibula, reduction tool, good spread of wires are the clinical importance of fibula transfixation wires. The Fig. 14 shows the difference of purchase in comminuted

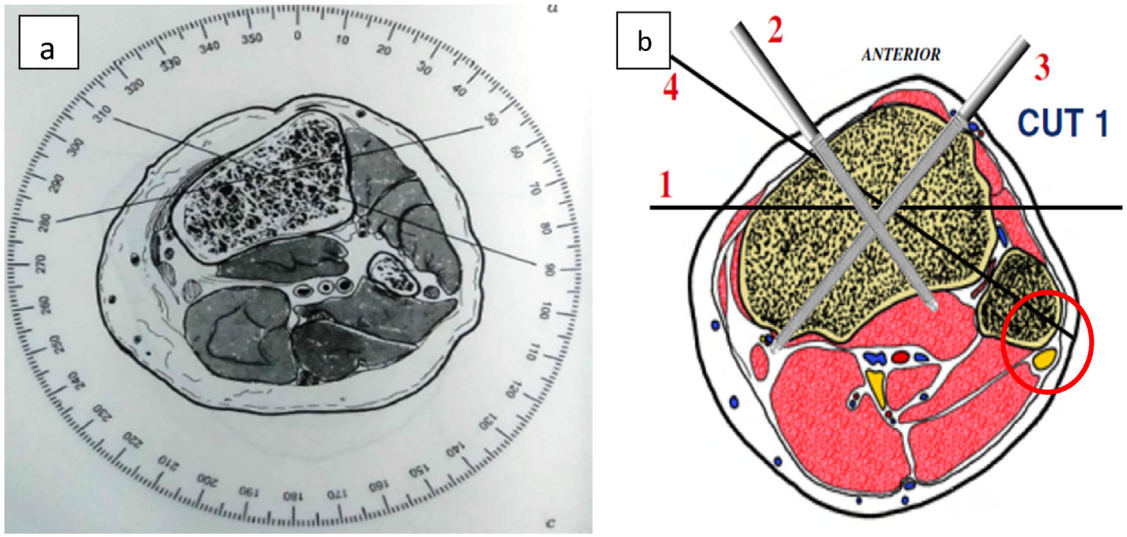


Fig. 13. (a,b) Variable recommendations of proximal fibula wire placements; Red ring shows close proximity of the nerve when placed through head of fibula as in Fig b.

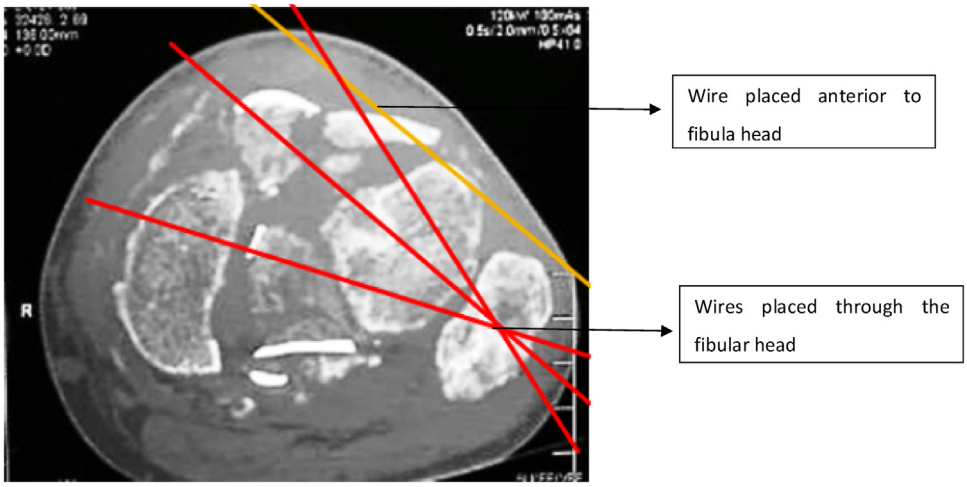


Fig. 14. Wires anterior to fibular head shows hardly any purchase on tibia but when given through fibula head we get good purchase and better hold of comminuted fragments.

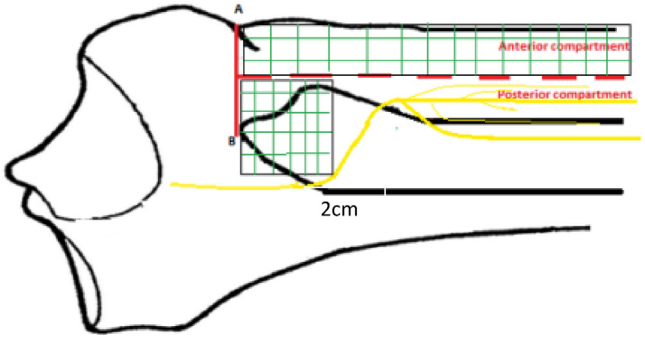


Fig. 15. Safe corridor for placement of proximal fibula transfixation pin. A – Tibial tubercle, B – Tip of styloid process of fibula. A perpendicular from AB parallel to fibula will divide in to anterior and posterior compartments. Green shaded area shows the safe corridor for wire placements.

fractures of proximal tibia when wires placed anterior and through the fibular head.

Safe corridor for placement of proximal fibula transfixation pin is proposed as shown in Fig. 15.

5. Conclusion

We conclude that the common peroneal nerve traverses the neck of fibula between 2–5 cm from tip of styloid process and nerve is at risk of injury in posterior third of fibular head. Peroneal fan even with variable course is posterior compartment of fibula. We recommend proximal fibula Trans fixation wires are safer to pass with in

1) 2 cm from the tip of the styloid process of the fibula, the danger zone lies in between 2–5 cm from tip of styloid process of fibula.
2) Anterior half of the head of fibula – Anterior 60% of head of fibula, open placement technique is advised if placed posteriorly.
3) <8% of total fibular length
4) Ventral half of the anterior compartment to avoid injury to peroneal fan.

The palpable landmark of fibula is a misinterpretation; it is just the prominent subcutaneous portion of fibula and not the styloid process of fibula. The styloid process up on dissection was located much posterior. Better to take fluoroscopic guidance in difficult cases where palpation of head of fibula is difficult.

The limitations of the study is small sample size, lack of comparison in between male and female in regarding to course of the nerve, lack of comparison with other palpable landmarks like gerdy's tubercle and joint line.

Source(s) of support

Nil.

Presentation at a meeting

Nil.

Conflicting Interest

Nil.

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