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Final Radiological Pattern of Bridging Callus Observed in Patients of Tibia Bone Fracture Tracked with Simultaneous Diagnostic Electric Stimulation.

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ABSTRACT

The ideal end result of fracture treatment is union. In present context radiographs are gold standard in fracture assessment. Present paper analyses how the fracture cases were followed up by diagnostic electrical stimulation along with radiographs ended with different types of union.

Keywords: Final radiological pattern, bridging callus, tibia bone fracture, diagnostic, electric stimulation

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INTRODUCTION

There is difference in analyzing a radiograph for assessing bone fracture union between orthopedic surgeons [1]. The actuality is that the existing gold standard to assess bone fracture healing The outcome measurement is the radiographic appearance. Recently electric stimulation is used as a diagnostic method to study bone fracture healing. Around 32 cases were studied till union. The method of electric stimulation and the outcome and the time of union is out of the purview of this paper. They are described in our earlier papers [2-5]. This paper only discusses the patterns of appearances of the callus in the radiographs and how the patients fared with this novel method. Here in this paper we aimed to collate details from appearances of all the cases followed with electric stimulation.

METHODOLOGY

The final radiological appearances of all cases treated with Ilizarov and followed with electric stimulation are compared and studied. The main outcome measurement was what was the shape of the callus and was it anatomical or not. If it was anatomical, how many cortices the bridging occurred and any affection of the return to daily pre-injury status or refractures.

Table 1: shows the details of all cases treated with Ilizarov and followed with electric stimulation

Case .no	Age	Sex	Diabetic	Fracture description	Fibula fracture level	Procedures before ilizarov	Anatomical or not	Number of levels of callus	Number of cortices of union
1	60	M	N	Med loss	?	Plaster	A	1	4
2	45	M	N	Medial wedge	same	Ef /Iln	NA	2	6
3	55	M	DM	Short obl	Same	EF SSG	A	1	4
4	25	M	N	Loss of bone	Higher level	Debride EF,Flap,	NA	1	More Posterolateral
5	35	M	N	Loss of bone	Nil	Debride EF,Flap,	A	1	postero medial aspect
6	17	M	N	Short oblique	Lower level	EF	A	1	4
7	50	M	N	Communit. Lateral	Same	Plaster	A	1	4
8	40	F	N	Oblique	Higher	Plaster	A	1	Telescopic
9	25	M	N	Bone loss	No details	Debridement EF,Flap, fibulectomy, bone grafting	NA	1	Massive
10	25	M	N	Medial bone loss	2 levels Lower closer to tibia fracture	Calcaneal pin	A	1	Except medial cortex
11	23	M	N	Short oblique	Higher level	EF	A	1	4 cortices
12	36	M	N	U /3 min bone loss	Same level	Plaster	NA	1	Telescopic
13	35	F	N	Medial wedge	Same level	Plaster	NA	2	Mass
14	50	F	N	Oblique	Slightly higher level	Plaster	A	1	4
15	50	M	N	Segmental	Near lower fracture	Plaster	A 2 levels	One each at both levels	4 at two levels
16	40	M	N	Oblique	Same	Plaster	A	1	4
17	50	m	N	Medial comminuted piece	Same	Plaster	NA	IRREGULAR	Massive
18	35	M	N	Wedge medial	same	Plaster	NA	Irregular	Massive
19	30	M	N	Short oblique	same	Plaster	A	1	Posterolateral
20	38	M	N	Comm.	Same	Plaster	NA	Mass	Telescopic

As seen from the table 1 there were non-anatomic union in few cases. The exact identity of these eight cases are 2^{nd} ,4^{th} ,9^{th} ,12^{th} ,13^{th} ,17^{th} ,18^{th} and 20^{th} cases. This was due to a non-anatomical fracture callus formation. This further implies that for some reason the exact apposition of the bone cortices in unfeasible or there was telescopy of the fragments into one another. In analyzing these cases, one should add that there were

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certain additional procedures done before the Ilizarov ring was applied in these eight cases. Two of these eight cases underwent musculo cutaneous flap cover. One case had fibulectomy followed by bone grafting both done elsewhere. The other cases either had loss of bone or a piece of bone like a wedge in the medial side. In these cases there was either a mass of callus or a callus across two fracture lines in one side and callus across one fracture line on the other. Thus the main factor that decides the type of callus is the status of the fracture. Rest of the cases (1,3,5,6,7,8,10,11,14,15,16,19) had minimal bone loss and one fracture line and hence had an anatomic union.

Figure 1: Case 1.A 60 year old gentleman a non diabetic had grade 3 open fracture of upper tibia with minimal bone. Fibula was not fractured. He had debridement and was put on Ilizarov ring . He went on to unite in 70 days. Anatomical, single level callus with the majority of the callus on both sides of the fracture , involving all 4 cortices. The patient was able to put weight comfortably

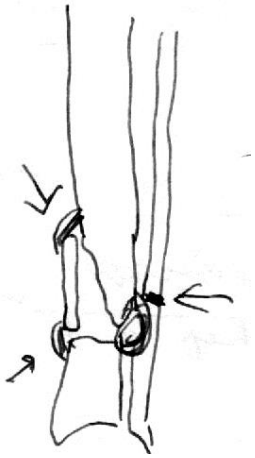

Figure 2: Case 2.A 39 year old gentleman a non-diabetic had a closed fracture which went to develop compartment syndrome and later had a fasciotomy, external fixator and split thickness skin grafting Fibula was fractured in same level as the tibial fracture indicating a slight degree of bending violence during the injury. Later he is external fixator was converted to interlocking nailing when the wounds healed. Still as the fracture did not unite and the nail got infected, the patient was put on Ilizarov ring. The patient went on to unite in 158 days. He had developed a non-anatomical, two level callus with callus in the both medial and lateral aspect posterior aspect bridging the fracture. The patient was able to put weight comfortably.

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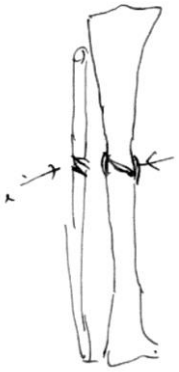

Figure 3: Case 3.A 55 year old gentleman a diabetic had grade 3 open fracture of middle third of the tibia with skin loss. He had debridement, split thickness skin cover and external fixator application in our hospital. Fibula was fractured in the same site as the tibial fracture indicating a degree of bending during the injury. The patient was put on Ilizarov ring and he went on to unite in 134 days. He developed anatomical, single level callus with the majority of the callus in the medial and lateral aspects bridging the fracture. He had four cortices united. The patient was able to put weight comfortably.

Figure 4: Case 4. A 25 year old gentleman a non-diabetic had grade 3 open fracture with bone loss-followed by debridement, flap cover and external fixator application in our hospital. Fibula was fractured in slightly higher place than tibial fracture indicating a slight degree of twisting during the injury. The patient was put on Ilizarov ring and had corticotomy and bone transport went on to unite in 355 days. Non anatomical, single level callus with the majority of the callus in the posterior aspect bridging the fracture.. The patient was able to put weight comfortably.

Figure 5: Case 5. A 35 year old gentleman a non diabetic had grade 3 open fracture with bone loss. He had debridement, flap cover and external fixator application in our hospital. Fibula was not fractured al all indicating a direct injury to tibia. The patient had ischemic heart disease and major surgeries were postponed for six weeks

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and he was put on cardiac drugs. Later he was put on Ilizarov ring and had corticotomy and bone transport went on to unite in 243 days. Anatomical, single level callus with the majority of the callus in the postero medial aspect bridging the tibial fracture.The patient was able to put weight comfortably.

Figure 6: Case 6. A 17 year old boy had grade 1 open fracture had debridement and external fixator application in our hospital. Fibula was fractured in slightly lower level than tibial fracture indicating a slight degree of twisting during the injury. The patient was put on Ilizarov ring and had correction and docking under image intensifier. He went on to unite in 187 days. He had an anatomical, single level callus bridging the fracture. The patient was able to put weight comfortably.

Figure 7: Case 7. A 50 year old male non diabetic had open fracture followed by a prompt debridement and ring application; there was comminution on the lateral aspect with fracture of the fibula. The union is faster than expected in 133 days, anatomical single level callus with four cortices.

Figure 8: Case 8. A 30 year old lady non diabetic had grade 1 open fracture followed by a conservative plaster application, and presented late. There was oblique fracture of the distal tibia with the fracture of the fibula in its

upper third indicating a twisting type of injury. The patient was put on Ilizarov ring fixator and went on to unite in 98 days. Anatomical single level callus with telescoping of the proximal fragment into the distal fragment.

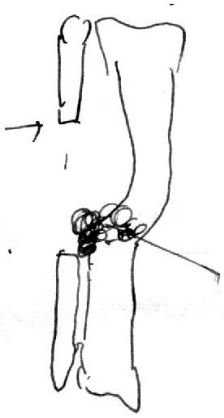

Figure 9: Case 9 .A 25 year old gentleman non diabetic had grade 3b open fracture with bone loss treated with debridement and Ilizarov ring application after initial external fixator and flap cover. This was followed by fibulectomy and posterolateral bone grafting done elsewhere. There was mild translation of the distal fragment of tibia fracture. The fracture of the fibula could not be assessed as there was fibulectomy. There was a non-anatomical single level callus with bridging of all the 4 cortices.

Figure 10: Case 10 . A 25 year old gentleman, a non diabetic had grade 3 open fracture followed by initial wound care and calcaneal pin traction. There was bone loss with tapering bone ends with fibula fractured in two places in its upper third and middle third indicating a direct type of injury. The patient was put on Ilizarov ring fixator followed by a bone grafting. He went on to unite in 159 days. Anatomical single level callus with callus in the posterolateral aspect. There was absent callus in the medial aspect. The patient was able to put weight comfortably.

Figure 11: Case 11. A 22 year old gentleman a non diabetic had grade 3 open fracture followed by debridement and external fixator application elsewhere. There was no bone loss with bone ends almost in apposition due to the fixator. Fibula was fractured in slightly higher place than tibial fracture indicating a slight degree of twisting

during the injury. The patient was put on Ilizarov ring and with no additional procedures went on to unite in 84 days. Anatomical single level callus with all the four cortices of tibia bridged. There was absent callus in the medial aspect. The patient was able to put weight comfortably.

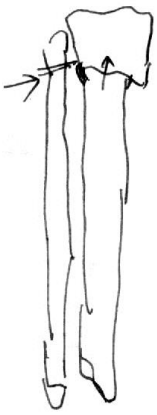

Figure 12: Case 12 A 36 year old gentleman a non diabetic had grade 3 open fracture with bone loss of upper tibia. He had debridement, acute docking of the fracture. Fibula was fractured in the same level as the tibial fracture indicating a bending element type of injury. The patient was put on Ilizarov ring and went on to unite in 127 days. Non anatomical, single level callus with the telescoping of the distal fragment into the proximal end bridging the fracture. The patient was able to put weight comfortably.

Figure 13: Case 13, A 35 year old lady a non diabetic had grade 1 open fracture with bone comminution -. Fibula was fractured in same level as the tibial fracture indicating a slight degree of twisting during the injury. Following debridement, the patient was put on Ilizarov ring. She went on to unite in 38 days. Non-anatomical, callus around a wedge shaped fracture site. Majority of the callus in the posterior aspect bridging the fracture. The patient was able to put weight comfortably.

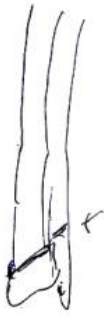

Figure 14: Case 14. A 50 year old lady, a non diabetic had grade 2 open fracture of the lower third tibia with fibular fracture slightly at a higher level than tibial fracture indicating a slight degree of twisting during the injury. The patient had debridement and Ilizarov ring application; she went on to unite in 50 days. She had anatomical, single

level callus with the majority of the callus in the posterior aspect bridging the fracture. The patient was able to put weight comfortably

Figure 15: Case 15.A 50 year old gentleman a non diabetic had segmental fracture of tibia with grade 3 open fracture in lower third and closed fracture in the upper third. His fibula was fractured in the same level as the lower tibial fracture indicating certain degree of bending violence during the injury. He had debridement and was put on Ilizarov ring. He went on to unite in 59 days. he developed an anatomical, single level callus with the majority of the callus in the lateral and medial aspect bridging the fracture. The upper closed fracture also went on to union. The patient was able to put weight comfortably.

Figure 16: Case 16. A 40 year old gentleman a non diabetic, renal patient had grade 3 open fracture of the tibia which was slight obliquity. Fibula was fractured in same level of tibial fracture. He had -followed by debridement and was put on Ilizarov ring and he went on to unite in 102 days. Anatomical, single level callus with the majority of the callus on either side of the fracture.The patient was able to put weight comfortably.

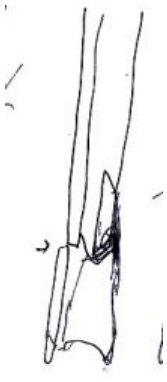

Figure 17: Case 17. A 50 year old gentleman a non-diabetic had grade 3 open fracture with comminuted bone pieces. Fibula was fractured in the same level as tibial fracture. He had debridement and was put on Ilizarov ring

and he went on to unite in 59 days. Non anatomical, single level callus with the majority of the callus in the medial r aspect bridging the fracture.. The patient was able to put weight comfortably.

Figure 18: Case 18 A 30 year old gentleman a non-diabetic had grade 3 open fracture with bone comminution with a sizable chunk of bone as a small segment between the two major fragments was in slight malalignment. Fibula was fractured in the same level as tibial fracture .Patient had debridement, Ilizarov ring fixator application in our hospital. The patient went on to unite in 105 days. The callus was non-anatomical, double level callus. The patient was able to put weight comfortably.

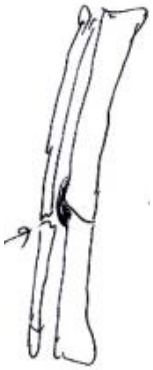

Figure 19: Case 19 A 25 year old gentleman a non-diabetic had grade 3 open fracture of middle third with bone comminution. Fibula was fractured in the same level as tibial fracture .Patient had debridement, Ilizarov ring fixator application in our hospital. His fracture united in 97 days Anatomical, single level callus with the majority of the callus in the postero lateral aspect bridging the fracture. The patient was able to put weight comfortably.

Figure 20: Case 20 A 40 year old gentleman, a polio patient and a non diabetic had grade 2 comminuted open fracture in a polio affected limb. Fibula was fractured in the same level as tibial fracture .Patient had debridement, Ilizarov ring fixator application in our hospital. He went on to unite in 110 days. The callus was non anatomical,

with both the major fragments telescoping into the comminution. There was abundant callus around these areas bridging the fracture. The patient was able to put weight comfortably.

All the patients had good function and returned to their pre-injury activities after the removal of rings and there were no refractures. All these 20 fractures had Teflon coated carbon rings; all were able to put weight on removal of the rings; all had electrical stimulation for the diagnosis which was corroborated with the radiographs. All the radiographs are available with the author and the hand drawn diagrams are given for better interpretation of the readers. In general whenever additional procedures are done as the fracture necessitates then the callus pattern becomes non anatomical. These are the cases where there is bone loss, gross injury with translation of the fragments.

DISCUSSION

Radiographs are the current gold standards upon which the decision of bone-fracture reduction and bone fracture union its acceptability to loading of the limb is depending. 20 cases of fractures of tibia bone were followed with radiographs and diagnostic electric stimulation. In our cases by anatomic union we mean a cortex to cortex union on either side in both anteroposterior and lateral radiographs. In any other form it should be called as a non anatomic union. The union is generally measured by the number of cortices that is bridged**.**

The shape of the tibial bone fracture line is obviously linked to the site of fibular fractures. Most of the fibular fractures are at or above the level of the tibial fracture, except one fracture which was surprisingly below the level of the tibial fracture. In contrast to what we saw in most cases , two cases which had bone loss, 5th and 10th especially had bone loss on the medial side, proper docking during transport followed by bone grafting (case5), and open docking in the other (case 10) led to good anatomic 3 cortex union.

According to the giant of fracture treatment Sarmiento, the final shortening and angulation observed in most of the segmental tibial fractures are not complications but only minor variations. [6] Function is more important than the structure. i.e. exact anatomical reconstruction and anatomic union is not necessary for both proper function. In all our 20 cases, the fractures united and in majority, with non-anatomical union. There is also proven in animal studies that more bone forms distal to the fracture site in femoral fractures and proximal to the fracture site in the tibial fractures. The ultimate structural mechanism used to remodel the callus is reversed from those of transverse bone growth. In long-bone growth there is equilibrium between periosteal appositional growth and bone resorption at the endosteal surface. But in remodeling of fracture callus there is exceptional spatial mechanisms to remodel from the outer side of bone to inside , thus balancing external removal bone with adding up of bone on internal surfaces [7].

CONCLUSION

In the 20 cases studied, there were different types of fractures which united with both anatomic and non-anatomic bridging. The irregularity of the current output stabilized if there was a union no matter whether it was anatomic or non-anatomic.

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