FRACTURE OF THE FIFTH METATARSAL BONE*

WITH SPECIAL REFERENCE TO DELAYED UNION

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Twenty-one cases of fracture of the fifth metatarsal bone will be considered to illustrate a tendency toward delayed union probably caused by poor blood supply. Knowledge of this tendency is necessary for prognosis and treatment.

Fig. 1.—Shows the epiphysis of the tuberosity in an eleven-year-old boy.

History.—Much has been written concerning fractures of the metatarsals. The interest in their evolutionary history lies in the fact that even to-day such fractures frequently go unrecognized, especially if produced by indirect violence. Cumulative evidence seems to show that writers have been puzzled by the long disability frequently accompanying the comparatively slow healing of fractured metatarsals. The "fussgeschwulst" (foot-œdema) of the Germans was first described by Breithaupt [1] in 1855. He noted that soldiers on the march were frequently disabled by painful, swollen and tender feet, he attributed this condition to strained ligaments and tendons. In 1877, Wiesbach [2] named it "syndesmitis metatarsea" and in 1884, Laub [3] referred to it as the "periostitis of fatigue." Pauzat [4] in 1887 interpreted this condition as an "osteoplastic periostitis"; in 1888, Poulet [5] described it as a "rheumatic osteo-periostitis", and in 1891, it was named "Inflammation periosto-arthritique du Pied" by Martin.[6] Then followed discussions by Rittershausen [7] and by Busquet.[8] It was not, however, until 1897, that Schulte [9] first thought that this condition was a fracture, and in 1898, Kirchner [10] definitely proved this theory by röntgeno-

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gram. Subsequently there have been many articles on the "marching fracture" of the British and Americans, the "pied forcé" of the French, and the "fussgeschwulst" of the Germans. Only recently Murk Jansen [11] has called attention to this condition. He believes that a spasm and pull of the fibres of the interosseous muscles produce either a subperiosteal hemorrhage or a disturbance in circulation to cause the bone thickening seen in the röntgenogram. Meiser [12] found in his statistics that only one-third of fractured metatarsals showed distinct evidence of the lesion in the X-ray picture. He also states that the röntgenogram does not show the formation of callus often before the tenth day and frequently not until three weeks after fracture. Massacré [13] also stresses the usual delay in bone repair. Weichelt [14] thinks that perfect union rarely can be accomplished in fractured metatarsals, especially when produced by a twist. Graham [15] reports the case of a man of fifty who had a fracture of the base of the fifth metatarsal caused by indirect violence. The first examination, five weeks after the fracture had occurred, showed that no union had taken place. Young [16] had a case of fracture of the distal end of the fifth metatarsal in which non-union was verified by X-ray. Removal of the head of this bone did not relieve the metatarsalgia, but subsequent exsection of the head of the adjacent bone produced some relief. All the foregoing facts seem to indicate the validity of the contention that "fussgeschwulst" is most likely due to a fracture of one of the metatarsals. It will later be shown how delayed union in some fractures of the fifth metatarsal could probably explain the picture presented in "fussgeschwulst".

FIG. 2.—The same bone shown in Fig. 1, at fourteen years and three months, to demonstrate the advance in ossification.

Statistics.—It is of interest to note the relative frequency of fracture of the metatarsal bones. In 491 cases, Kirchner [17] found the fractures distributed as follows:

I	II	III	IV	V
0	253 (52%)	198 (40%)	32 (6%)	8 (2%)
	Distal Third 52%	Middle Third 42%		Proximal Third 6%

TABLE I.

*Synoptical Table of Twenty-one Cases of Fracture of the Fifth Metatarsal.**

No.	Age	Sex	Trauma Direct	Trauma Indirect	Site and type of fracture	Weight bearing	Length disability	Laboratory findings	Follow-up	Remarks
149173	25	F	+		Distal end of shaft, transverse, head displaced mesially	14 weeks	6 months	Urine—negative Wassermann—negative Blood calcium....10.04 } mgs. per Blood phosphorous 2.5 } 100 c.c.	Union in about 20 weeks, with some pain and swelling beneath malleolus. At 9½ months slight pain around ankle and swelling beneath malleoli on walking. Slight tenderness at site of fracture	False point motion at 12 weeks. Delayed union.
128576	40	F		+	Base—Transverse—no displacement	9 weeks	6 months	Urine—negative Wassermann—negative. Blood calcium.....9.45 } mgs. per Blood phosphorous 3.8 } 100 c.c.	2½ years. Slight tenderness over site of fracture. Some residual decalcification of metatarsals	Rarefaction of metatarsals predominant in X-ray. Delayed union.
131625	31	M	?	?	Base—transverse, comminuted	6 weeks	11 weeks	Urine—negative Wassermann—negative Blood calcium.... 10.9 } mgs. per Blood phosphorous 3.3 } 100 c.c.	28 months—no symptoms or signs. By X-ray thickening of bone at site of fracture	Delayed union.
130169	34	M		+	Base, complete—no displacement	6 weeks	3 months			Probably delayed union.
120159	34	F	+		Base—no displacement	5 weeks	4 months			Probably delayed union.
117073	24	F		+	Distal end shaft—slight displacement proximal fragment	4 weeks	3 months		4 months—no symptoms or signs	
130590	26	F	?	?	Base—transverse, no displacement	5 weeks	3 months		6 months—no symptoms or signs	

142498	41	F	+		Distal end shaft, incomplete, transverse	4 weeks	3 months	Urine—negative Wassermann—negative Blood calcium 10.02 \ mgs. per Blood phosphorous 2.54 / 100 c c.	16 months—no symptoms or signs. X-ray shows firm union	
149373	56	F		+	Tuberosity	8 weeks	3 months	Urine—negative Wassermann—negative Blood calcium .... 9.55 \ mgs. per Blood phosphorous 2.9 / 100 c.c.	3 months—considerable œdema dorsum foot-tenderness at site of fracture. X-ray shows moderate amount callus	
118592	60	M		+	Base—transverse, no displacement	6 weeks	2 months		13 weeks—no symptoms or signs	
143848	19	F		+	Tuberosity	4 weeks	1½ months	Urine—negative Wassermann—negative	1 year—no symptoms or signs	
113604	46	F		+	Base—incomplete	2 weeks	5 weeks		3 months—slight swelling about ankle on walking	
126070	47	M	+		Base, transverse, lateral displacement distal fragment	22 days	5 weeks			
111749	50	F		+	Base	4 days	4 weeks			
109343	35	M	+		Tuberosity	3 weeks	4 weeks			
17668	41	M		+	Shaft—comminuted, no displacement	2 weeks	2 weeks			
136100	41	M	+		Shaft—middle third, oblique		Did not return			
133746	55	F	+		Shaft—proximal third, oblique		Did not return			
121326	20	M		+	Base—no displacement		Did not return			
115829	19	F	+		Base—transverse		Did not return			
132158	13	M		+	Base, transverse epiphysis tuberosity present		Did not return			

*The predominating symptoms and signs in all the cases were pain, swelling, ecchymosis, and tenderness. They were immobilized either by a posterior moulded plaster splint for the foot and leg or by a plaster boot. The cases that were followed received physiotherapy at frequent intervals.

Summarizing 233 cases, Nion [18] found the fracture 115 times on the right side and 118 times on the left.

Anatomy.—The fifth, the most exposed of the metatarsal bones, is one of the smallest, yet one of the strongest of them all. It develops a separate osseous centre in the distal end between the third and the fifth years, and sometimes as late as the eighth year. Between the eighteenth and the twentieth years the epiphysis unites with the shaft. Kirchner [19] describes a separate epiphysis for the tuberosity, which Gruber[20] believes to be only occasional. On the other hand, Schouwey [21] found it constant and occurring in the thirteenth and fourteenth years. In one specimen that he examined microscopically he was able to demonstrate that the centre of ossification is first developed in the tendon of the peroneus brevis. Figure 1 shows the epiphysis of the tuberosity in a boy of eleven and Fig. 2 shows the advance in ossification in the same bone at fourteen years and three months. The base, tuberosity, shaft and head make up the entire bone. The tuberosity, rather prominent and nipple shaped, projects on the lateral aspect of the base, which, by a posterior facet, articulates with the cuboid, and, by a mesial facet, with the fourth metatarsal. The shaft differs from any of the other metatarsals in being compressed from above downward, instead of from side to side, so that it presents superior, inferior and mesial surfaces. The head is small, turned somewhat laterally, and has a pair of lateral tubercles at the end of the dorsal aspect of the shaft. The muscle and ligamentous attachments are shown in Fig. 3.

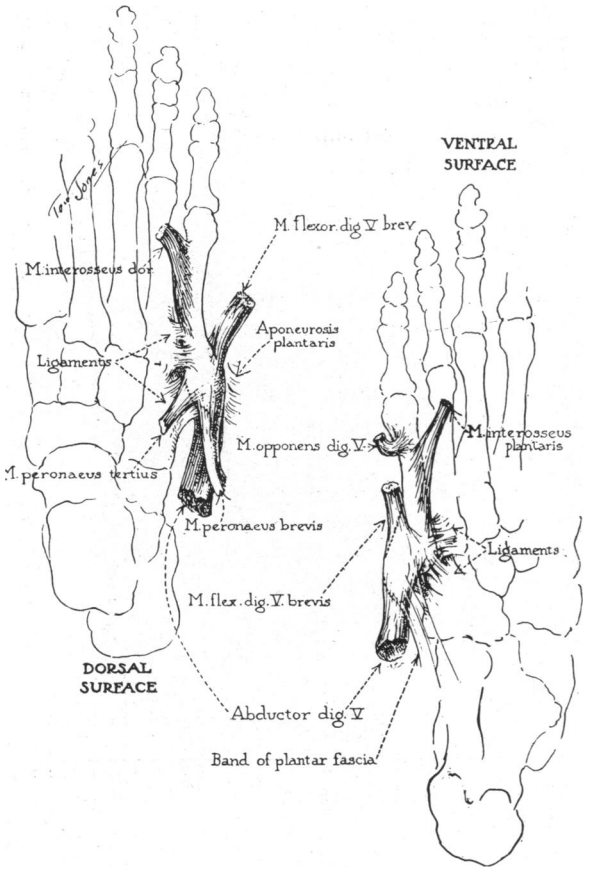

FIG. 3.—The muscle and ligamentous attachments to the fifth metatarsal. (From Christopher [32].)

Blood Supply.—Comparison shows that the rate of union in fractured

metacarpals is more rapid than that in metatarsals, and that the calibre of the blood-vessels supplying the former is larger than that of the blood-vessels supplying the latter. In addition, weight-bearing tends to compress the branches of the plantar arch. The nutrient vessel of the fifth metatarsal, which, according to Piersol,[22] may be absent, enters by a foramen usually situated on its tibial side, and it is significant that this vessel is as a rule directed toward the base. (Fig. 4.) It is represented only by a few fine branches which anastomose with the small blood-vessels of the epiphyses. The latter are more abundant than the former. Johnson,[23] in his work on the blood supply of the diaphysis, concludes that the factors essential in bone repair are, in the order of importance, the nutrient artery, and the vascular networks of the metaphysis and of the periosteum.

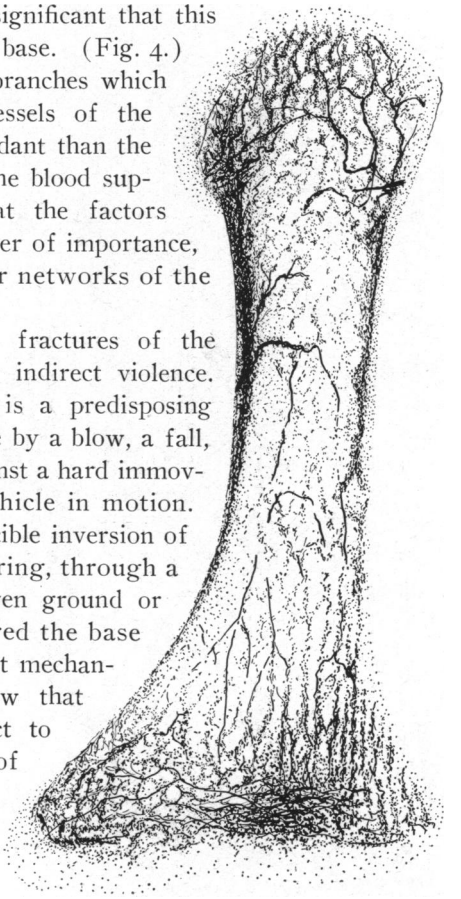

FIG. 4.—The blood supply of the fifth metatarsal. Note the fine primary nutrient vessel and the small blood-vessels of the epiphyses. (From Lexer [33].)

Mechanism.—The mechanism of fractures of the fifth metatarsal is through direct or indirect violence. The exposed position of this bone is a predisposing factor for its injury by direct violence by a blow, a fall, striking the outer side of the foot against a hard immovable object, and by a wheel of a vehicle in motion. The indirect violence is usually a forcible inversion of the foot accompanied by weight-bearing, through a fall, a jump, a sudden step on uneven ground or dancing. Sir Robert Jones [24] fractured the base of his own fifth metatarsal by the last mechanism. A glance at Fig. 5 will show that whereas the proximal end is subject to strain by plantar fascia and a pull of peroneus brevis and tertius, the distal end is acted upon by the dorsal and plantar interossei and the opponens digiti quinti.

An analysis of twenty-one cases given in table shows the following:

1. Sex: Males, 9 (47 per cent.). Females, 12 (53 per cent.). 2. Age: Youngest, 13 years. Oldest, 60 years. Average, 36 years.

		Base	Tuberosity	Shaft	Distal Extremity	Total
3. Violence	Direct	3 (38%)	1 (12%)	2 (25%)	2 (25%)	8
	Indirect	7 (64%)	2 (18%)	1 (9%)	1 (9%)	11
	Doubtful	2 (100%)				2

4. Predominant symptoms and signs—pain, swelling, ecchymosis and tenderness.

5. Length disability (16 cases): Shortest, two weeks. Longest, twenty-four weeks. Average, ten weeks. 6. Females tend to have a longer disability than males. 7. The end results are good.

A further analysis of the 20 cases in adults shows that there were five cases which from clinical and X-ray evidence had delayed union. This occurred four times at the base and once at the distal extremity of the shaft. All the other cases that could be followed had characteristic pain, tenderness

A B

FIG. 5.—Case No. 149,173. To show a fracture of the distal extremity of the shaft of the fifth metatarsal nine days after injury.

and œdema at and surrounding the area of fracture, which extended over periods of weeks or months. While it is true that soft part injury in association with the fracture might produce these symptoms for a short period, still interference with proper bony union is the most plausible explanation for the long disability.

One would expect in a long bone as small as the fifth metatarsal, that enough union would take place in the cancellous portion in about ten days to

prevent mobility of the fragments. In the cortical bone of the shaft, normal calcification should occur in about three weeks. When delayed union occurs, some attempt at repair is being made, but it is slow nevertheless. Estes [25] considers delayed union to have taken place when it becomes evident eight days or more after the upper limit. When union has taken place, abnormal mobility cannot be detected at the site of fracture. This, however, has no relation to the strength of repair. When there is abnormal mobility after six months, non-union is said to have occurred. The relative frequency of delayed union in all bones is variously given by different authors. Nutter [26] quotes Boyd and also Von Bruns, who estimate that it occurs in about 1¼ per cent. of fractured limbs. Hey Groves,[27] however, gives the frequency between four and five per cent. The usual causes for delayed union are, excluding compound and badly comminuted fractures:

FIG. 6.—The same as Fig. 5, after one month. Note the very slight callus on the mesial aspect of the fracture line.

1. Circulatory disturbance. 2. Infection. 3. Syphilis. 4. Low calcium and phosphorus content of the blood (Petersen).[28] It will be seen that all the factors except circulatory disturbance have been eliminated from the group of cases under consideration.

The type of bone repair in fractured metatarsals is rather interesting. Several varieties of callus may be formed.

1. It may be so small as to be scarcely visible in the X-ray. This is especially true when there has been no displacement of fragments.

2. It may be excessive and form the so-called "cal vicieux." This frequently occurs when the fracture has been overlooked and the patient walks about. It may be so large as to impinge on an adjacent metatarsal or cause pressure on the plantar nerves.

3. It may be long and thin, stretching almost the entire length of the shaft.

4. It may be delayed for a long time and then appear quickly or slowly.

It must be remembered, however, that the time for the appearance of callus in the X-ray is variable. Twenty-two days after fracture of a metatarsal, Kirchner [17] found a thick callus by röntgenogram which could not be easily detected on examination. Thiele [29] found no callus fifteen days after such a fracture, but fifteen days later it was marked. This bears out

A B

FIG. 7A.—The same as Fig. 5, after three months, when false point of motion could still be elicited. Note the slight amount of callus mesially and apparently none laterally. The bones of the foot are rarefied. B. Showing rarefaction of the bones of the foot.

the observation that there may be apparent inactivity in callus formation for several weeks and then calcification may occur quite rapidly.

Treatment.—On the basis of all the foregoing facts, the treatment recommended is as follows:

1. Immobilization of the foot and leg by means of a posterior moulded plaster splint. Crutches may be used.

2. Measures such as deep light therapy and gentle massage to promote hyperæmia. These methods are better with the foot in the splint.

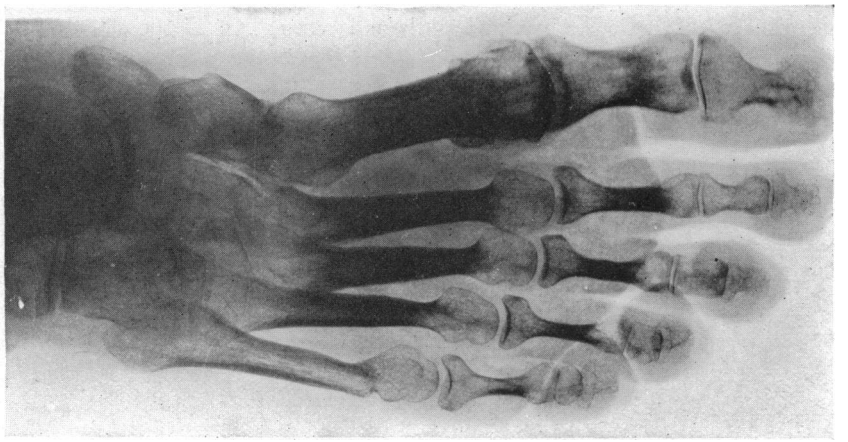

FIG. 8.—The same as Fig. 5, after six months, showing union.

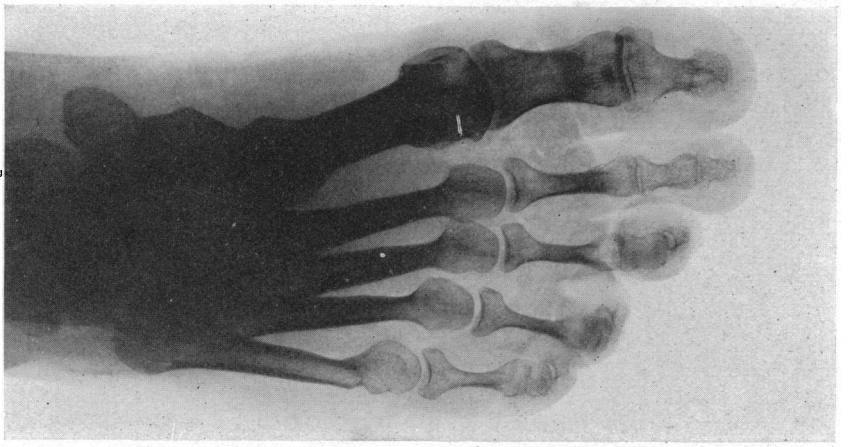

FIG. 9.—Follow-up röntgenogram of Fig. 5, after nine months showing firm union. Note the thin callus rounded off.

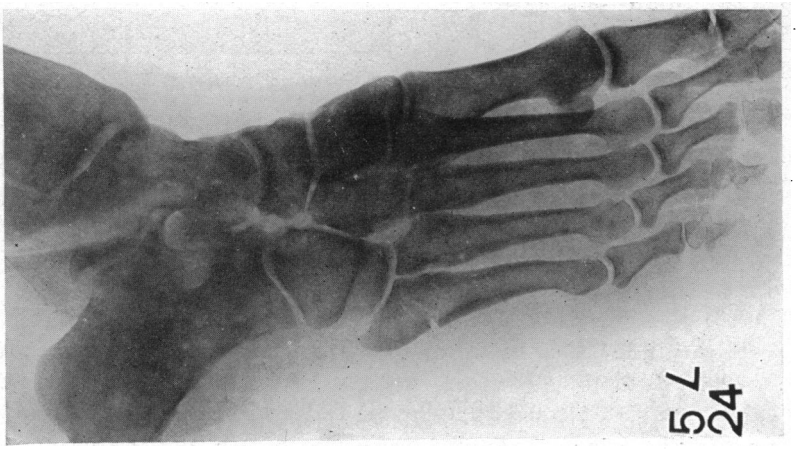

FIG. 10.—Case No. 131,625. To show a transverse, comminuted fracture of the base of the fifth metatarsal bone.

3. If there is a tendency to delayed union, the administration of calcium [30] or cod liver oil, heliotherapy, and perhaps scarification of the fractured ends with a needle introduced through the soft parts in order to produce bleeding. The last is recommended by Darrach [31] in some cases of non-union.

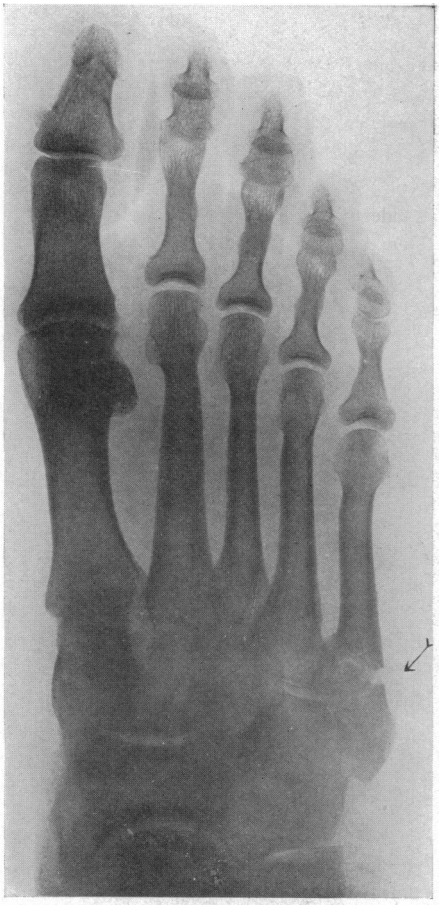

FIG. 11.—The same as Fig. 10, after one month. Note that there is only very slight callus formation.

FIG. 12.—The same as Fig. 10, after twenty-eight months, to show perfect union and considerable thickening of the bone at the site of fracture.

4. Avoidance of excessive trauma to demonstrate mobility of the fragments.

Prognosis.—This must be guarded as to the time and extent of disability. The best prognosis can be given for fracture of the tuberosity.

Summary.—Twenty-one cases of fracture of the fifth metatarsal are reported, with their analysis. Twenty were in adults, and of these five showed clinical and X-ray evidence of delayed union. All the latter had a normal blood calcium and phosphorus and a negative urine and blood Wassermann. All the other cases that could be followed had clinical symptoms over such long periods that it is fair to assume some interference in bone repair. The

main cause of this condition is probably the poor blood supply of this bone. The treatment is directed toward immediate immobilization and hyperæmia. The experience from all these cases tends to show that too long immobilization produces bone atrophy which certainly cannot help bone repair. Weight-bearing in a strong moulded plaster splint before one month, where possible, is suggested to overcome this bone atrophy. Between the eleventh and sixteenth years, the epiphysis of the tuberosity is not to be mistaken for fracture.

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