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Department of Orthopaedic Surgery O-Ø, Odense University Hospital, Odense, Denmark.

QUADRICEPS FUNCTION FOLLOWING FRACTURES OF THE FEMORAL SHAFT IN CHILDREN

V. Damholt & D. Zdravkovic

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It is generally agreed that in children conservative treatment is preferable to operative treatment of fractures affecting the femoral shaft. Serious complications are rare (Barfod & Kristensen 1958, Burwell 1969). In assessing late results particular interest has been displayed in the growth accelerations (with subsequent disparity of limb length) (Guldhammer 1963). In the endeavour to contribute to further objective parameters, we investigated quadriceps function by measurements of its isometric strength and dynamic endurance in patients with a history of such fractures during childhood.

MATERIAL

The material is derived from the Odense University Hospital, 1955–1967, and comprises children aged 0–15 years with fracture of the femoral shaft without other associated fractures or injuries to vessels or nerves. In addition, the material was selected so as to be of an approximately equal distribution in the age groups 0–4, 5–9, and 10–14 years. Records were collected from 1955 onwards. The collected records were divided into three pools which were closed when each comprised 20 patients. Thus, each pool had an age range of five years. The minimum follow-up period was 2 years and the earliest age at follow-up was 15 years. Fractures of the femoral shaft were taken to be all fractures located from the inferior edge of the lesser trochanter down to 2 cm above the distal epiphyseal line. Of the 60 patients selected 57 attended follow-up. Among these 57 patients four had to be excluded, as one suffered from severe intellectual impairment, one had patellar chondromalacia, one sequelae to numerous ankle distortions, and one clinical signs of marked asymmetry of the muscles in the right and left lower limb.

Figure 1 gives the age distribution and sex ratio. The age distribution is fairly equal, but no patient was between 0 and 2 years. The ratio girl/boy was one/three. Table 1 presents the level and type of fracture (according to Dencker 1963). Only two patients had open fractures. The two sides were equally affected, 27 fractures being on the right and 25 on the left side. Forty-eight patients reported being

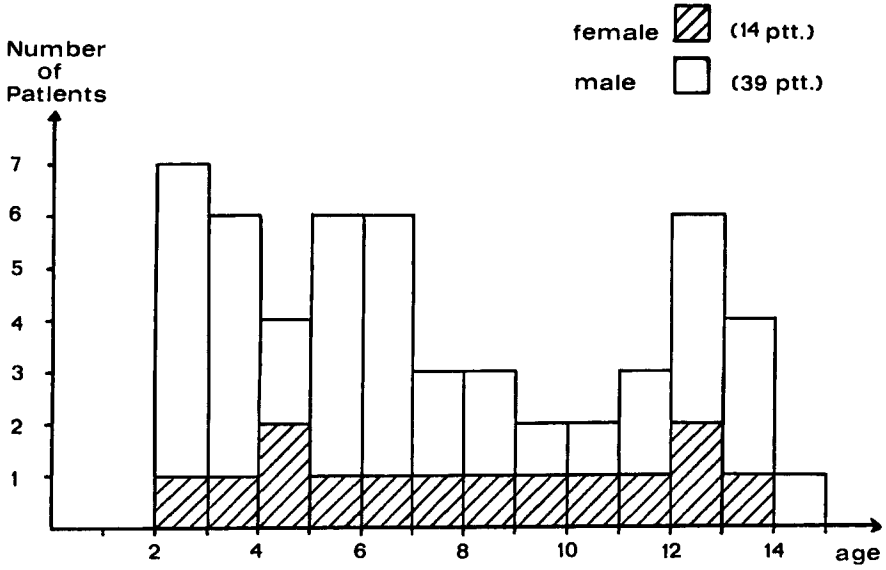

Figure 1.

"right-legged" (preferring the right leg in strength and precision achievements) and 5 "left-legged".

Table 1. Type and level of fracture in the 53 patients.

Type	No. of patients
Short oblique	6
Long oblique	22
Transverse	14
Comminuted	11
Level	
Upper third	13
Middle third	36
Lower third	4

Treatment

All 53 patients had primarily been treated by traction (52 by plaster traction and one by skeletal traction on the tibial tuberosity). In four cases the treatment was later supplemented by plaster casts. One week after application of the traction six patients were treated by open reduction and osteosynthesis, four by Parham's

band, one by a Lane plate, and one by a single screw. The duration of traction and the time of mobilization are shown in Tables 2 and 3. Most patients were out of bed 4–8 weeks after the accident. None were subjected to a special physical therapy training programme. Two patients had brief, superficial infection. One of them had been treated by a Lane plate and the other one by a single screw. None had developed osteitis. In the remaining 51 patients no complications occurred.

Table 2. Duration of traction.

Duration in days	No. of patients
≦ 28	17
29–42	30
≧ 43	6

Table 3. Duration of bed rest.

Duration in days	No. of patients
≦ 28	0
29–42	27
43–56	13
≧ 57	13

METHOD

At follow-up all femora were X-rayed. Measurements were made of the circumference of the thigh 8 and 15 cm above the patella, the length of the lower leg from the knee line to the tuberosity of the calcaneus, as well as of the isometric strength and dynamic endurance according to a method described previously (Damholt & Zdravkovic 1972).

RESULTS

All the patients seen at follow-up were free of pain and had full extension as well as flexion of at least 120° at the knee. Four had complaints in the form of fatigability in the affected limb. One had 20° medial and 15° dorsal angulation, one had 10° ventral and one 10° medial angulation of the distal fragment. Fifteen exhibited a 0–2 cm lengthening of the affected leg and two patients 1 and 2 cm shortening respectively. One of those patients had undergone epiphysiodesis on

the unaffected leg. Table 4 sets out differences in circumference exceeding 2 cm as compared with the unaffected leg, measured 15 and 8 cm above the patella. The circumference of the affected leg was on an average 0.5 cm less that that of the contralateral leg. This difference is significant (T-paired test: 3.50, d.f. 52, $P < 0.001$).

Table 4. Difference in circumference of more than 2 cm, 15 and 8 cm above the patella on the affected limb as compared with the unaffected one.

Level above patella	No. of patients	
	Decrease in circumference	Increase in circumference
15 cm	9	1
8 cm	3	1

Table 5. Percentage difference in isometric strength and dynamic endurance.

	Percentage difference	No. of patients	
		Isometric	Dynamic
Affected leg stronger	$\geqq$ 20.1	1	2
	20.0–10.1	2	4
	10.0– 0.1	11	4
No difference	0.0	4	6
Unaffected leg stronger	0.1–10.0	19	9
	10.1–20.0	8	11
	$\geqq$ 20.1	8	17

Table 6. T-testing of the results of strength measurements in relation to age (T-paired test).

Patients age in years	0–4	5–9	10–14
No. of patients	15	23	15
Isometric	T=1.59, d.f.: 14 $P > 0.05$	T=1.05, d.f.: 22 $P > 0.05$	T=3.04, d.f.: 14 $P < 0.01$
Dynamic	T=2.97, d.f.: 14 $P < 0.05$	T=2.00, d.f.: 22 $P > 0.05$	T=4.39, d.f.: 14 $P < 0.001$

Table 7. Percentage difference in isometric strength and dynamic endurance in the 33 patients whose affected leg was also the preferred leg.

	Percentage difference	No. of patients	
		Isometric	Dynamic
Affected leg stronger	≧ 20.1	1	2
	20.0–10.1	3	3
	10.0– 0.1	7	3
No difference	0.0	3	1
Unaffected leg stronger	0.1–10.0	11	6
	10.1–20.0	4	8
	≧ 20.1	4	10

Table 5 presents the percentage difference between the strength of the affected and the unaffected leg. Measurements of isometric strength showed the fractured leg to be stronger than the contralateral leg in 14 patients. In four cases there was no difference. Thirty-five of the fifty-three patients had reduced strength of the affected leg, with a maximum reduction of 36.8 per cent, mean 12.9 per cent. The results of measuring dynamic endurance are also listed in Table 5. In 10 cases the affected leg was stronger than the unaffected one. In 6 cases there was no difference. The remaining 37 patients showed a reduction of dynamic endurance in the affected leg, maximum 45 per cent, mean 19.5 per cent. This reduction in endurance was significant (isometric strength: T-paired test: 3.18, d.f. 52, $P < 0.01$; dynamic endurance: T-paired test: 4.43, d.f. 52, $P < 0.001$). From Table 6 it is apparent that only the oldest group exhibited a significant reduction of isometric strength and dynamic endurance in the affected leg. The measurements in the four patients whose fractures had affected the distal third of the femur did not differ from those in the group as a whole.

An investigation was made to detect a correlation between circumference and strength of the affected and unaffected leg. In the case of the unaffected leg there was a significant correlation between circumference and both measurements of strength (isometric strength: $r = 0.50$, $P < 0.001$, dynamic endurance: $r = 0.34$, $P < 0.05$). In the case of the affected leg there was no significant correlation between circumference and isometric strength ($r = 0.23$, $P < 0.05$), but between circumference and dynamic endurance ($r = 0.27$, $P < 0.05$).

Comparison of the strength measurements in the affected and unaffected leg in 33 patients (Table 7) in whom the affected leg was simultaneously the "preferred" leg showed no difference in isometric strength (T-paired test: 1.87, d.f. 32, $P > 0.05$), but a significant reduction of dynamic endurance on the affected side (T-paired test: 3.14, d.f. 32, $P < 0.01$).

DISCUSSION

The literature is very sparse with respect to elucidating muscle function following fractures of the limbs, and this function is rarely used as a criterion for assessing the therapeutic results particularly in children. The status of the muscles after femoral fractures has often been evaluated by measurements of circumference, but direct measurements of quadriceps function have not been carried out. In a previous study (Damholt & Zdravkovic 1972) a significant reduction in isometric as well as in dynamic strength on the fractured side was found in two-thirds of adult patients, and Heebøl-Nielsen (1964) has found abnormal weakness (exceeding 15 per cent) in a similar material. In children there was a significant reduction of strength and abnormal weakness in more than one-third. However, the materials are not comparable, as the severity of the fractures differed when assessed by comminution (in about half the adults and only one-fifth of the children), and as the routine treatment of the adults was by osteosynthesis giving direct access to the fracture, whereas practically all the children were treated conservatively. The reduction in dynamic endurance was more marked than that of isometric strength, and this finding is in accordance with previous studies. Reduction of strength proved to be most pronounced in children of the oldest age group. Measuring the circumference in assessing the muscle status on the fractured leg seems to be of limited value, as it was correlated only with dynamic endurance, whereas in the unaffected leg it was correlated with both measurements. Also, it was not possible to demonstrate a consistently better muscle strength in the group where the affected leg was also the preferred leg. There was no definite relationship between the results of the dynamic and isometric measurements, most patients having mild reduction of isometric strength and pronounced reduction of dynamic endurance in the affected leg. That selective training of one muscle function need not necessarily entail changes of other muscle functions has also been demonstrated in

previous studies on patients with fracture of the femur (Damholt & Zdravkovic 1972) and in normal subjects (Hansen 1967).

A previous study by the present authors (Damholt & Zdravkovic 1972) revealed a tendency to greater reduction of strength the more distally the fracture was located. The level of fractures in children is characterized by a low percentage in the distal third of the femur (Barfod & Kristensen 1958, Burwell 1969). Our material included only four patients having fractures in this site, and they did not differ from the series as a whole.

SUMMARY

Fifty-three selected patients, treated in the Odense University Hospital for femoral fractures in childhood during the period 1955 to 1967, were investigated for quadriceps function by measurements of isometric strength and dynamic endurance. Forty-seven had been treated conservatively, the remaining 6 by osteosynthesis. Isometric as well as dynamic measurements revealed a significant reduction of strength in the affected leg. Measuring the circumference of the fractured leg to assess its muscle status appears to be of limited value when correlated only to dynamic endurance, whereas in the unaffected leg it was correlated to both measurements. Moreover, it was not possible to demonstrate consistently greater muscle strength in the group in which the affected leg was also the preferred leg.

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Correspondence to:

Villiam Damholt
Ortopædisk-kirurgisk afdeling
7500 Holstebro, Denmark