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QUADRICEPS FUNCTION FOLLOWING INDIRECT NAILING OF FEMORAL SHAFT FRACTURES

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A series of 24 adult patients with isolated, unilateral fractures of the femoral shaft treated by indirect Street-Hansen nailing is submitted. Follow-up included clinical and radiological assessment as well as measurement of quadriceps power. Isometric strength as well as dynamic endurance were significantly decreased at the 5 per cent level as compared with the unaffected leg. There was a poor correlation between thigh circumference and strength. The decrease in strength and endurance after indirect nailing was less than that found in previous investigations of femoral fractures treated by direct nailing.

Key words: quadriceps; function tests; strength; fracture of femoral shaft, sequelae

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The most important requirements in modern treatment of fractures are the achievement of union as well as normal physical and social function in the shortest possible span of time and with the least possible risk to the individual patient (Charnley 1963). But as this involves several factors, the question of priority arises – and thus variations in the choice of treatment as well as in the assessment of the therapeutic results.

In the Odense University Hospital the routine treatment of fractures of the femoral shaft has been for several years traction in children and intramedullary nailing by a massive, rhombic Street-Hansen nail in adults. Up to 1969 the operation involved open reduction with retrograde introduction of the nail. Since that time the routine surgical procedure has been closed reduction, introducing the intramedullary nail from the greater trochanter to the femoral condyle under transillumination. As an additional parameter in the assessment of the therapeutic results, we have introduced measurement of the strength of the thigh muscles.

In 1972 the present authors submitted the therapeutic results of fractures of the femoral shaft in adults and in 1974 those in children, with special attention to muscle function (Damholt & Zdravkovic 1972, Damholt & Zdravkovic 1974).

PATIENTS

In this paper we are submitting the results of treatment of unilateral fractures of the femoral shaft in adults, having no other injuries, by closed reduction and indirect nailing by the Street-Hansen method.

The material comprises 24 patients, 6 females and 18 males in the age range 16–66 years, mean age 25 years. The follow-up period ranged from 2–6 years, mean 2.7 years.

Table 1 gives the situation in which the accidents occurred. The majority of patients had

Table 1

Place of accident	No. of patients
Traffic	20
Work	2
Home	1
Sport	1

Table 2

Type of fracture	No. of patients
Long, oblique	0
Short, oblique	9
Transverse	11
Comminuted	4
Level of fracture on the femur	
Upper third	3
Middle third	21
Lower third	0

sustained their injury in traffic accidents. According to data from the case records and renewed history taking, the trauma could be evaluated as direct in 21 and indirect in 3 patients. Two fractures were complicated.

Table 2 lists the type and level of the fracture, classified according to Dencker (Dencker 1963). The distribution does not differ much from previous findings except that no fracture involved the lower third of the femur.

METHOD

All patients underwent their operation within 2 weeks of the trauma, two-thirds of them within the first 48 hours. The principle of after-treatment was exercises in bed immediately after the operation. Within 1 week the patients were out of bed, with permission for weight-bearing granted individually according to the nature of the fracture.

At follow-up an X-ray was taken of the femur to assess its axis and union. Measurements were made of active movements in the knee joint, the circumference of the thighs 8 and 15 cm above the patella, isometric strength, dynamic endurance, and knee extension. The length and rotation of the leg were assessed clinically. In addition, information about a few physical and social functions was obtained. Measurements of muscle strength and the calculations involved have been described previously (Damholt & Zdravkovic 1972).

RESULTS

All the operative wounds healed by primary intention. At follow-up all the fractures had united. In none of the patients did the angular deformity exceed 10° – according to the X-ray appearances.

One patient with a short oblique fracture on the middle of the femur had a 4 cm shortening of the affected leg. In the others the difference in leg length never exceeded 2 cm. All the patients had normal knee extension and knee flexion exceeding 90°. Three had a very slight rotation deformity of the affected leg. Visible asymmetry was not present in any of the others. Of the 24 patients, 23 had been permitted unrestricted weight-bearing within 3 months of the operation and the remaining patient in $3\frac{1}{2}$ months.

In two patients it was not possible to carry out a measurement of dynamic endurance; one of them had recently had a myocardial infarction and the other one had severe, bilateral osteoarthritis of the knees.

The results of measuring strength and endurance are shown in Table 3. In six cases measurement of isometric strength and in four the measurement of dynamic endurance showed the affected leg to be stronger than the unaffected one. In four and three cases, respectively, there was no difference. Thus, the majority fell into the group in which the affected leg was weaker than the unaffected one. Within this group the maximum difference in isometric strength was 52 per cent and that in dynamic endurance 75 per cent. On the average, the affected leg was 10.5 per cent and 12.2 per cent weaker than the unaffected one on measurement of isometric strength and dynamic endurance, respectively. This difference is statistically significant.

Isometric strength paired t test = 2.1 d.f. 23 $P < 0.05$.
Dynamic endurance paired t test = 1.99 d.f. 21 $P < 0.05$.

In two patients the circumference of the affected femur was 2.5 cm smaller than that of the unaffected one. In all the others the

Table 3. Results of measurement of strength

	%	Isometric strength No. of patients	Dynamic endurance No. of patients
A > U	⩾ 20.1	1	1
	20.0–10.1	1	1
	10.0– 0.1	4	2
A = U	0	4	3
A < U	0.1–10.0	4	7
	10.1–20.0	4	3
	⩾ 20.1	6	5

A = affected leg, U = unaffected leg.
The measurements of strength were calculated according to the formula: U–A in per cent of U.
Calculation formula of isometric strength and dynamic endurance worked out in collaboration with Sv. Molbech, M.Sc., of the Polio Institute, Hellerup/Copenhagen (1971). (Formula obtainable on request from the authors.)

Table 4. Results of strength and endurance measurements in patients under and over 25 years of age. Figures in brackets indicate number of patients

	Percentage decrease of strength in affected leg:	
	Isometric	Dynamic
Patients under 25 years (18)	6.5	7.5
Patients over 25 years (6)	22.8	33.3

circumference showed no difference or a difference of less than 2 cm.

The results of measuring strength were compared with the measurements of circumference. For isometric strength the correlation coefficient was $r = 0.39$ and for dynamic endurance $r = 0.49$. Thus, the corresponding determination coefficients r^2 were 0.15 and 0.24, respectively. In other words, a variation in one parameter can explain only 15 per cent and 24 per cent, respectively, of the variation in the other.

At follow-up 22 of the 24 patients were employed in the same or heavier work than before the accident. Two patients were not employed: one was out of work and one was attending school.

Prior to the accident 10 of the patients had been involved in competitive sport. Of them 6 went back to the same sport. Comparison of patients involved in sport and those who were not showed no statistically significant difference in the results of strength measurements.

Table 4 gives the mean decrease in isometric strength and dynamic endurance in the affected leg in per cent of the unaffected one – for patients under and over 25 years of age. There is a clear tendency towards a more marked decrease of strength in the older patients, but owing to the small number involved the difference is not statistically significant at the 5 per cent level. Two patients with rotation deformity showed a decrease of 24 per cent and 43 per cent in the affected leg

Table 5. Comparison of statistical calculations in which the measurements of strength and endurance in the affected leg are related to the unaffected leg

	I		II		III	
No. of patients	53		33		24	
Isometric strength	$t=6.42$	$P<0.001$	$t=3.18$	$P<0.01$	$t=2.1$	$P<0.05$
Mean decrease	30.6%		12.9%		10.5%	
Dynamic endurance	$t=5.4$	$P<0.001$	$t=4.43$	$P<0.001$	$t=1.99$	$P<0.05$
Mean decrease	33.0%		19.5%		12.2%	

Group I: Fractures treated by direct nailing.
Group II: Conservatively treated fractures in children.
Group III: Fractures treated by indirect nailing.
t = Student's test.

in isometric strength and dynamic endurance, respectively. The patient having a 4 cm shortening also had a decrease of strength, of 30 per cent and 75 per cent, respectively.

DISCUSSION

As parameters in evaluating the results of treatment of fractures of the femoral shaft we have introduced measurements of muscle strength and endurance. The present study is a continuation of our investigations into quadriceps strength in patients treated for fractures of the femoral shaft.

The 1972 series included 53 adults treated by open reduction and direct intramedullary nailing by the method of Street-Hansen (Group I). The series from 1974 comprised 33 children treated by traction (Group II). Danckwardt-Lilliestrom & Sjögren, in 1976, used the same principle for measuring strength and endurance in a series of 23 patients, but only 17 of them had been treated by intramedullary nailing alone. In the present study we followed 24 patients with fractures of the femoral shaft without other injuries (Group III).

Table 5 lists the results of isometric strength and dynamic endurance measurement of knee extension in patients with fractures of the femoral shaft – treated by the three methods mentioned above.

The decrease of dynamic endurance was greater than that of isometric strength in all cases. The ratio between these two measurements was approximately the same in all three series. On the other hand, the decrease in isometric strength as well as in dynamic endurance in the affected leg was considerably greater in group I patients, treated by open reduction (mean about 30 per cent) than in group III patients, treated by closed reduction and indirect intramedullary nailing (mean about 12 per cent). The results for children (group II) treated by traction are intermediate between those for groups I and III, but closer to the latter.

Conclusion

In group I from 1972, treated by direct nailing, the mean decrease in strength was about 30 per cent, which is definitely abnormal. In the present material treated by indirect nailing the mean decrease was only about 10 per cent, and in patients under 25 years of age it was considerably less. This difference is within the range of normal for symmetrical muscle groups (Heebøll-Nielsen 1964). In other words, the indirect method of intramedullary nailing has shown obvious advantages over the direct, open method. The former, moreover, obviates further traumatization of the muscles and reduces the risk of secondary infection at the fracture site.

REFERENCES

Charnley, J. (1963) *The closed treatment of common fractures*, 3 ed., Livingstone, Edinburgh.

Damholt, V. & Zdravkovic, D. (1972) Quadriceps function following fractures of the femoral shaft. *Acta orthop. scand.* **43**, 148–156.

Damholt, V. & Zdravkovic, D. (1974) Quadriceps function following fractures of the femoral shaft in children. *Acta orthop. scand.* **45**, 756–763.

Danckwardt-Lilliestrom, G. & Sjögren, S. (1976) Postoperative restoration of muscle strength after intramedullary nailing of fractures of the femoral shaft. *Acta orthop. scand.* **47**, 101–117.

Dencker, D. M. (1963) *Fractures of the shaft of the femur.* Orstadius Boktryckeri Aktiebolag, Göteborg.

Heebøll-Nielsen, K. R. (1964) Muscular asymmetry in normal young men. Commun. Test Obs. Dan. Nat. Ass. Inf. Paral. No. 18.

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