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PATELLECTOMY

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Removal of the patella has been practised since 1860 (Putz, according to Cohn 1944). It is considered a comparatively modest operation which generally does not give rise to major complications. Nevertheless, its justification has been the subject of heated discussion, at times with subjectively coloured contributions and ideas based on different interpretations of the development and especially the function of the patella.

In respect to development, the patella is not present in amphibia, reptiles, or in certain mammals. In most mammals it is embedded in the quadriceps tendon, with no possibility of major excursion (De Palma 1954). In a human foetus of only 20 mm the structure of the quadriceps muscle has been laid down. In addition, there is a faint increase in the number of mesenchymal cells anteriorly, i.e. at the site of the patella (Walmsley 1940). In a 30 mm foetus the first cartilage cells are seen, and in a 40 mm foetus 3 layers of the quadriceps muscle may be distinguished:

A. The superficial layer passing down anteriorly to the patella and inserting itself anteriorly into the patellar ligament.

B. The intermediate layer inserting itself into the fibrous layer anteriorly to the cartilaginous patella.

C. The basal layer which maintains its muscular characteristics until it inserts itself proximally into the patella.

The patellar ligament is formed of the fibrous layer anteriorly to the patella, as well as of fibres issuing from the inferior pole of the patellar primordium (Bruce & Walmsley 1942). According to these authors, the patella is an integral part of the extensor apparatus, the superficial layer corresponding to the rectus, the intermediate layer to the vastus cedialis and lateralis, and the basal layer to the vastus intermedius. Others, *inter alios* Broke (1937) and Hey Groves (1937),

believe that phylogenetically the patella is a rudimentary bone which undergoes reduction and in time is going to disappear entirely and that it is situated posteriorly to the tendon without making up part of it.

The patella increases relatively in size up to the sixth foetal month. Thereafter, it shows relative diminution up to the second or third year of life. At 3–4 years of age the ossification centre is visible, and at 17–18 years ossification is complete.

The patella has several functions. According to Haxton (1945), Jensenius (1951), and others, the following factors are of importance:

1. It acts as an intermediate link of cartilage cells, making friction cartilage to cartilage instead of cartilage to tendon. Bruce & Walmsley (1942) and Cohn (1944), on rabbits, and De Palma (1958), on dogs, found that after removal of the patella degeneration of the cartilage started on the patellar surface of the femur and that later bone lesions and other osteoarthritic changes developed in the entire joint.

2. It takes part in transmitting force from the quadriceps muscle to the lower leg. The patella makes the lever (the distance from the tendon to the transverse axis of the knee joint) longer in extension as well as in flexion. The patella plays a more important part in extension, whereas in flexion it dis*appears*, more or less, into the intercondylar fossa. However, the axis is not a fixed point, but shifts to the anterior aspect in extension, i.e. the lever becomes shorter: These two last-mentioned factors may explain why Brooke (1937) found most strength in the quadriceps muscle in 90° flexion after removal of the patella, studied on patellectomized patients as well as in experiments on cadavers. On the other hand, Haxton (1945) and O'Donoghue (1952) found that in all positions of the knee joint strength is greater with than without the patella. The former author found that strength was greater in extension, the latter that it was greatest in 90° flexion and that the loss of the patella was most perceptible in full extension. In other words, there is a marked conflict between the results. Another factor is the angle between the long axis of the quadriceps muscle and the patellar ligament which is smaller with than without the patella. This ought to result in more force being expended on pressing the patella towards the femur than on pressing the tendon against the femur. To this is added the difference in friction cartilage/cartilage versus cartilage/tendon.

3. It protects the knee joint in direct trauma.

4. It is of cosmetic value.

The clinical results are also conflicting. Brooke (1937) submitted a material of 30 patients subjected to patellectomy following fracture of the patella, who made a "rapid and smooth recovery" in 2–3 weeks, returned to full-time jobs, e.g. climbing ladders, within 4–6 weeks, with a quadriceps strength above that of the normal leg. Scott (1949), on the other hand, found that out of 101 patients treated for patellar fracture by patellectomy, only 5 per cent considered the knee as good as the other one, 90 per cent had pain, and 60 per cent complained of instability. Wass et al. (1942) found similar poor results. Friberg (1941) reporting 32, Ostenfeld (1954) 14, Haliburton et al. (1958) 136, and Duthie et al. (1958) 56 patellectomies, comprising patients with osteoarthritis as well as patellar chondromalacia, found that patellectomy was of value, and their results were intermediate between the two above-mentioned extremes. However, Duthie et al. as well as O'Donoghue (1952) found subjective as well as objective reduction of strength and instability in 30–50 per cent and corresponding atrophy of the thigh. In two-thirds of his patients Friberg (1941) demonstrated a "drawer" sign. One sequel to the operation is calcification in the tendon which may be demonstrated by palpation as well as X-ray. The aetiology may be either pieces of bone left behind or transformation of the tendon tissue due to the strong, persistent action. In Friberg's (1941) opinion this reduces the function of the knee, whereas Duthie (1958) believes that it is of no consequence. Inhibition of existing osteoarthritic processes was found by Geckeler et al. (1962) as well as by West (1962), but only when assessed by clinical criteria. Hoffer et al. (1966) found no such reduction in the osteoarthritic process.

PRESENT INVESTIGATIONS

The material comprises 72 patients, 30 females and 42 males, patellectomized in the Orthopaedic Hospital, Copenhagen, during the period 1945–1959. As 4 operations were bilateral, there are 76 operated knees, 41 right and 35 left knees. Out of the 72 patients, 6 had died and 4 are living abroad. 62 were examined by the author, and all but 2 had X-rays of both knees in 2 projections. The follow-up period ranged from 1–20 years, average 6 years. At the time of operation the youngest patient was 10 years and the oldest 76. The material is divided into 5 disease groups: Recurrent dislocation of the patella, chondromalacia of the patella, fracture of the patella, osteoarthritis of the knee, and rheumatoid arthritis. It is realized, of course, that often these condi-

Table 1. Age distribution and number of operated knees classified by disease

	< 30 yrs	30–39 yrs	40–49 yrs	50–59 yrs	60–69 yrs	> 70 yrs
Dislocation of the patella	3	2	0	3	0	1
Chondromalacia of the patella	2	6	9	6	1	0
Fracture of the patella	10	5	4	3	2	0
Osteo-arthritis	1	0	2	7	3	2
Rheumatoid arthritis	1	1	0	2	0	0
Total	17	14	15	21	6	3

tions overlap and that in the great majority of cases there are more or less pronounced osteoarthritic changes as a consequence of the main disease. Table 1 sets out the age distribution and the disease groups. Within the group of patellar fracture, 5 patients had immediate or almost immediate patellectomy in the Orthopaedic Hospital, 7 had been primarily treated elsewhere by cerclage, and 12 had primarily been treated by conservative measures.

The *indication* for patellectomy has not always been clearly mentioned in the case notes, and at times certain data concerning the preoperative condition were lacking. In 63 patients (one bilaterally operated) the main indication was pain at rest and/or at work, combined with reduction in strength and minor limitation of movement. In 8 cases considerable limitation of movement, increasing to contracture, had been the main indication, and in 6 cases instability and/or a tendency to dislocation of the patella.

The *operation* was usually done in a bloodless field through a transverse incision into the skin, longitudinal incision in the tendon, and sharp dissection of the patella. In some cases a parapatellar incision had been used. As far as possible, the defect in the tendon was sutured, but in one case a fascial graft had to be used because the defect was too large and the tendon was lacerated.

Postoperative management ranged from ordinary elastic bandage over a posterior splint to circular plaster for 1–6 weeks. Training of the quadriceps was instituted immediately, and weight-bearing was allowed within the first 2 weeks in the absence of complications. In patients who did not have plaster, active movements of the knee joint were allowed after one week. 26 patients were treated with plaster, 21 of them for 3–6 weeks.

Table 2. Number of patients having pain at rest and at work before the operation and at follow-up

	Pain at rest		Pain at work	
	Preop.	At follow-up	Preop.	At follow-up
Dislocation of the patella	4	2	8	6
Chondromalacia of the patella	16	13	24	20
Fracture of the patella	7	6	15	11
Osteo-arthritis	12	4	14	8
Rheumatoid arthritis	4	2	3	3
Total	43	27	64	48

RESULTS

Pain. As already mentioned, the main indication for patellectomy was pain. It is difficult to grade pain. Therefore, Table 2 should be compared with Table 3. 27 patients (43 per cent) still have pain at rest and 48 (75 per cent) have pain at work. The large number of patients with patellar chondromalacia who still have pain is remarkable. The changes in the knee in this disease, especially in its early stages, are localized in the femoro-patellar joint. Therefore, patellectomy would be expected to have a favourable effect on this disease.

Mobility. Tables 4 and 5 list the flexion and extension defects before the operation and at follow-up. A flexion defect was more common, and is stated in 3 groups: 10°–30°, 30°–60°, and more than 60°. There does not seem to have been any striking improvement in this respect. Particularly within the group of patellar chondromalacia, there were 4 cases of flexion defect after the patients had been treated postoperatively by circular plaster for 3–6 weeks.

Table 3. Patients' own assessment at follow-up

	Poor	Fair	Good	Not examined
Dislocation of the patella	3	1	3	2
Chondromalacia of the patella	11	5	7	1
Fracture of the patella	6	8	8	2
Osteo-arthritis	4	3	4	4
Rheumatoid arthritis	2	1	0	1
Total	26	18	22	10

Table 4. Number of patients having a flexion defect before the operation and at follow-up (normal excursion 0°/130°)

	30°–60°		0°–30°		More than 60°	
	Preop.	At follow-up	Preop.	At follow-up	Preop.	At follow-up
Dislocation of the patella	0	0	2	1	3	2
Chondromalacia of the patella	2	3	4	3	0	4
Fracture of the patella	1	1	0	2	10	5
Osteo-arthritis	0	2	4	1	4	5
Rheumatoid arthritis	1	1	0	0	2	1
Total	4	7	10	7	19	17

In 8 patients whose main complaint was limitation of movement, the patella had been removed in an attempt at improving mobility. No excessive loosening of the extensor apparatus, ligaments, or capsule had been done. In these cases the results are stated in degrees, extension being 0° and full flexion 130°, first the preoperative mobility and then the mobility at follow-up:

0°/0°–0°/130°; 0°/10°–0°/50°; 0°/50°–0°/30°; 45°/90°–45°/90°; 0°/5°–5°/15°; 0°/0°–0°/0°; 10°/60°–0°/45°; and 0°/10°–0°/20°.

Among these patients there were 4 with complicated fracture of the femoral shaft and 2 with fracture of the femoral neck, treated primarily by wire traction and later by operation or conservative measures, followed by plaster.

"Quadriceps femoris muscle". Instability and reduced strength, subjective as well as objective, after patellectomy is probably due mainly to insufficiency of the quadriceps muscle. There is a considerable increase in the number of patients complaining of instability (from 19

Table 5. Number of patients having an extension defect before the operation and at follow-up (defect stated in degrees)

	Preoperative	At follow-up
Dislocation of the patella	5°	10°
Chondromalacia of the patella	10°–10°–15°	5°–10°
Fracture of the patella	10°	5°
Osteo-arthrosis	10°–20°–20°–20°–40°–45°	10°–10°–20° ! !
Rheumatoid arthritis	5°–25°–40°–45°	25°–30°

Table 6. Number of patients with muscular insufficiency. Atrophy and strength compared with the "normal leg"

	Instability		Atrophy of thigh after operation		Strength of the muscle after operation	
	Preop.	At follow-up	1–2 cm	More than 2 cm	Slightly reduced	Greatly reduced
Dislocation of the patella	4	4	7	2	2	3
Chondromalacia of the patella	5	18	14	8	11	8
Fracture of the patella	5	10	11	9	5	9
Osteo-arthritis	5	5	6	5	2	4
Rheumatoid arthritis	0	0	1	3	1	1
Total	19	37	39	27	21	25

to 37 or 58 per cent). Table 6 lists the atrophy of the thigh found at follow-up, in two groups with atrophy of 1–2 cm and of more than 2 cm as compared with the normal leg, in one case of 11 cm. (Preoperative measurements were lacking in so many cases that a comparison cannot be made). Table 6 also gives the strength of the quadriceps muscle at follow-up in relation to the normal leg, measured by making the patient lift weights from 90° flexion to an extended position. At follow-up 5 patients had arthrodesis in the knee joint, 5 could not stand even the slightest from of strain because of pain, and 3 had had bilateral operation. 5 patients showed equal strength on both sides, 21 had slightly reduced strength, and in 25 the strength was reduced to less than half that in the normal knee. 23 patients complained of difficulty in walking—12 of them especially in climbing stairs. 9 used a stick, 1 used 2 sticks, and 4 periodically used a splint.

Tendon changes. In 1 case the tendon had ruptured and active extension was abolished. In another case a defect was palpable centrally in the tendon, but function was comparatively satisfactory by way of the retinaculae. 1 patient had a tendency to lateral dislocation of the tendon, and in one the tendon had become fixed to the anterior aspect of the femur and active function was lost (this was the patient who had a fascial graft).

X-ray changes. Table 7 lists the radiological osteoarthritic changes prior to the operation and at follow-up, divided into 3 degrees of severity. At the bottom of the Table is given osteoarthritic changes in the "normal" knee. It will be seen that in spite of removal of the

Table 7. Number of patients with radiological changes and at follow-up, in severity of osteoarthritis

	Osteoarthritis grade 1		Osteoarthritis grade 2		Osteoarthritis grade 3	
	Preop.	At follow-up	Preop.	At follow-up	Preop.	At follow-up
Dislocation of the patella	4	2	2	2	0	2
Chondromalacia of the patella	16	11	0	8	0	0
Fracture of the patella	1	7	7	8	1	1
Osteo-arthritis	4	2	2	2	5	4
Rheumatoid arthritis	2	0	0	1	2	2
Total	27	22	11	21	8	9
"Normal knee"	23	26	3	7	5	5

patella, the existing osteoarthritic process cannot be arrested. It progresses apparently at a more rapid rate than expected judging by the "normal" knee.

More localized changes at the patellar surface of the femur were present preoperatively in 36 patients and in the same number at follow-up (Table 8). According to the previously mentioned animal experiments, a larger number might perhaps be expected to have shown these changes at follow-up. It may be mentioned that 3 of the 5 patients who had immediate operation for fracture of the patella did not

Table 8. Number of patients with radiological changes at the site of the patellar surface of the femur, osteoporosis and bone formation in the tendon

	Patellar surface of the femur		Osteoporosis		Bone formation in the tendon
	Preop.	At follow-up	Preop.	At follow-up	
Dislocation of the patella	6	4	7	4	2
Chondromalacia of the patella	10	12	8	16	13
Fracture of the patella	10	10	11	11	15
Osteo-arthritis	7	8	8	10	4
Rheumatoid arthritis	3	2	2	2	3
Total	36	36	36	43	37

Table 9. Period off work (per knee)

	Long period off work before op.	Period off work after the operation		
		0–2 mths	2–6 mths	7–12 mths
Dislocation of the patella	2	1	3	3
Chondromalacia of the patella	5	3	11	8
Fracture of the patella	0	1 acut 4 seq.	3 acut 9 seq.	1 acut 4 seq.
Osteo-arthritis	2	2	4	4
Rheumatoid arthritis	1	0	0	2
Total	10	11	30	22

show any radiological changes at the site of the patellar surface of the femur.

Radiological signs of osteoporosis were seen preoperatively in 36 cases and in 43 at follow-up. Visible bone formation was present in 37 cases at the site of the patella. In one case the entire patella had regenerated. In this case it had been necessary at the patellectomy to chisel out the entire patella in small pieces.

Period off-work and working ability (Tables 9 and 10). 10 patients had been off work for more than 6 months prior to the operation. Among these 10 patients 2 had been off work for 2–6 months after the operation, 5 for 7–12 months, and 3 have been awarded disablement pension (in 2 cases, however, for other reasons).

Table 10. Number of patients who had to change to lighter work or who were completely incapacitated and number of arthrodeses on the knee

	Change of occupation	Disablement pension, etc.	Arthrodesis
Dislocation of the patella	0	2 (both from other causes)	0
Chondromalacia of the patella	12	2 (1 diss. sclerosis)	2
Fracture of the patella	3	2 (1 old-age pension)	3
Osteo-arthritis	1	4 (1 old-age pension) (1 cerebr. haemorr.)	0
Rheumatoid arthritis	0	2 (all joints involved)	0
Total	16	4 due to the knee disease 8 due to other causes	5

Out of the 72 operated patients 11 had returned to their previous work within 2 months after the operation, 30 had been off work for 2–6 months, and 22 for 7–12 months before they had more or less regained their working ability. 16 patients changed to lighter work, 4 patients were awarded disablement pension mainly because of their knee disorder, and 8 because of other diseases. Five patients later underwent arthrodesis (2 cases of patellar chondromalacia and 3 with sequelae to patellar fracture). 11 patients were repeatedly described by psychiatric terms, before and after the operation and by a number of different doctors. At follow-up 10 of these patients were assessed as mentally normal by the author.

Patients' own assessment (Table 3). 26 patients described their condition as poor, no better than before the operation. 18 felt that the result was fair. They had periodical complaints, but in between they were better than before. 22 were completely satisfied. Their knee was quite good, although not in all cases up to the normal knee.

DISCUSSION

The results do not strike one as particularly brilliant, but are in keeping with those reported by most previous authors. The present material comprises mainly knee joints with fairly long-standing changes, in particular changes which had often involved other parts of the joint also. Assessed on the basis of the radiological appearances, it does not appear possible to influence an existing osteoarthritic process by removing the presumed cause. On the other hand, there seems to have been a moderate reduction in the number of patients having pain at rest and/or at work. About one-third of the patients reported that they were fully satisfied with the operation and the present condition of the knee, and about one-quarter were fairly satisfied. When also considering the relatively serious articular changes, patellectomy must be assigned a place in the treatment of these diseases. However, the patient must be prepared for a relatively long postoperative course and considerable muscular insufficiency. The latter might, no doubt, be reduced by intensive quadriceps training not only during the immediate postoperative period but for several years. Aftertreatment in plaster does not seem to be necessary and may cause a flexion defect.

Patellectomy does not do much in the way of loosening knee contractures, no doubt because the contractures affect the muscles, ligaments, and capsule as well (cf. Sommerville 1960 and Nicoll 1963).

The present material is not suited for assessing whether the patella is necessary in an otherwise normal knee joint. Viewed on the basis of the literature and the late sequelae, such as instability, reduced strength, difficulty in walking, and atrophy of the thigh, it would seem that the patella does have a function in transmitting force to the lower leg.

SUMMARY

The function of the patella is outlined, in particular its function in transmitting force to the lower leg. Experimental as well as clinical studies appear to indicate that the patella serves a useful function. A follow-up study on 62 patellectomized patients, including 4 bilateral cases, is submitted. Moderate alleviation of pain was found, but patellectomy had caused insufficiency of the quadriceps muscle and did not appear able to arrest existing osteoarthritic processes. Nevertheless, the operation must be assigned a place in the treatment of some serious disorders of the knee.

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