

RISK OF UNTOWARD REACTION TO USE OF CATGUT IN OSTEOSYNTHESIS

By

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In certain cases it may sometimes seem preferable to use catgut rather than wire, particularly for the fixation of bones in children, in whom the increasing growth in thickness of the bone may necessitate later extraction of the wire and consequently another operation. If the bone has thickened considerably, the removal of the wire may require a fairly difficult operation.

In the course of the last few years I have occasionally used silk and in a few cases also catgut in fractures of the femoral diaphysis in children. The cases were followed-up for about two months, by which time the fractures had consolidated; they were not reviewed later.

About a year ago I operated on a male adult for a fracture of the lower leg and afterwards observed an insidious but marked bone resorption, evidently caused by the use of catgut. This untoward reaction induced me to study the suitability of catgut in osteosynthesis. The results of the investigation described further on will be preceded by a report of the case history of this patient.

Case-history. A 31 year old man had sustained a spiral fracture of the right lower leg. When first seen there was also a small surface wound in the anterior aspect of the lower leg, but no signs of an open fracture. The wound ran a fair course and healed in 8-10 days. The patient was treated first with a plaster cast and later with plaster + traction, but as no satisfactory results were achieved, open reduction was decided upon and the operation was performed 18 days after admittance. Open reposition was performed and the fracture was fixed with four double subperiosteal catgut slings, use being made of ordinary Nr. 2 catgut kept in 95 p.c. alcohol. The wound was sutured and the leg immobilized in plaster, traction being maintained. The post-operative course was smooth and primary healing was obtained.

Roentgenographic review 30 days later revealed an initial resorption of the cortex in the neighbourhood of the catgut sutures. Three months after the operation the fracture had healed clinically and roentgenographically, but resorption

had increased considerably (see Fig. 1) so that the patient was discharged with a walking-plaster, which he used for about another two months. The leg showed no signs of inflammation and was clinically healed, but the defects due to resorption persisted. After another 6 weeks, i.e. six months after the operation, a fistula developed, and a piece of catgut was extracted, and some time later another fragment. The fistula then healed rapidly and the defects gradually disappeared.

Many papers are available on osteosynthesis and the suitability of various suturing materials for such operations, but only a few touch

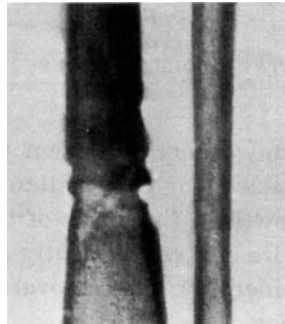


Fig. 1.
Resorption three months
after the operation.

upon the use of catgut and the reaction of the bone tissue. There are very few articles available on the subject, and the authors do not seem to agree. *Lexer*, for example, observed that catgut sutures in bone transplantation cause the formation of granulation tissue which has a deleterious effect on the graft. *Koelsch* studied the reaction to catgut in fractures in rabbits and fixed the fragments (fibula) with catgut drawn through a hole drilled in the bone. He found that the formation of callus was impaired "indem es resorbierendes Bindegewebe anlocht", and that resorption was greatest in those parts around the drilled hole that were compressed by the catgut, whereas in other areas of the hole there was a wide osteoblastic seam. Others such as *König* and *Dahl-Iversen* observed no untoward reaction of the tissue to catgut. The latter used thick chrome-tanned ribbon gut for fixing horn plates. According to *Dahl-Iversen*, a large amount of granulation tissue and numerous giant cells were observed around the catgut, but no signs of lacunar resorption were to be seen. *Watson-Jones* claims that a strong catgut suture tied tightly round a bone can cause sufficient bone absorption to produce an almost spontaneous fracture.

AUTHOR'S EXPERIMENTS

Double catgut Nr. 1 was wound around the lower part of the femur of full grown rabbits. The catgut was that usually employed at our clinic and had, as usual, been kept in 95 per cent alcohol. In five rabbits the catgut was laid subperiosteally and in the others over the periosteum. In nine cases the catgut was tied with a triple knot and in the remaining four it was not tied at all, and in a few instances control tests were made with silk thread and wire. The wound healed without complications in all cases except two, which were then excluded from the series. The animals were roentgenographed at intervals of 8 to 10 days, and in a few cases histological examinations were also carried out. The results are given in the following table.

Group	Animal Nr.	Periosteal reaction		Resorption		Remarks
		After-time in days	Degree	No. of days before observed	Grade	
Thread knotted	42	38	—	45	++	Exam. histol. after 63 days
	43a ¹	17	++	52	++	Exam. histol. after 63 days
	43b ¹	—	—	21	—	Exam. histol. after 3 weeks
	44	—	—	38	++	
	45	17	++	63	+	
	46	—	—	38	+++	Spontaneous fracture on 56th day
	49a ¹	—	—	52	+++	
Thread not knotted	49b ¹	25	++	75	++	
	48	25	+++	96	?	
	47	25	—	96	—	
	50	—	—	18	—	Exam. histol. after 18 days

Nrs. 43, 54, 48 and 50—the catgut was applied subperiosteally.

¹ Bilateral but not simultaneous operations.

It is apparent from the table that in all those cases in which the catgut was tied, there occurred a vigorous resorption of the cortex at the sites where the catgut was applied. In rabbit Nr. 43 b the experiment was already terminated after 3 weeks and in Nr. 50, after 18 days, when the animals were killed for histological examination. As a rule the resorption was roentgenologically visible after about six weeks. In two of the experiments (43, and 45) a periosteal reaction,

in the form of small fringed deposits, was observed after 2-5 weeks (see Figs. 2 and 6). In two of these cases the wire catgut had been applied subperiosteally. No essential difference was observed between the rate and stage of resorption of the cortex in the legs in which the catgut was applied over the periosteum, and in those in which the material had been applied subperiosteally.

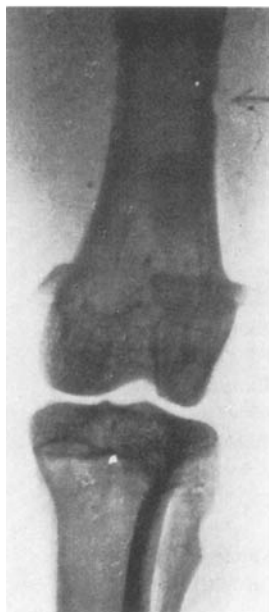


Fig. 2.

Nr. 42. 45 days after the operation.

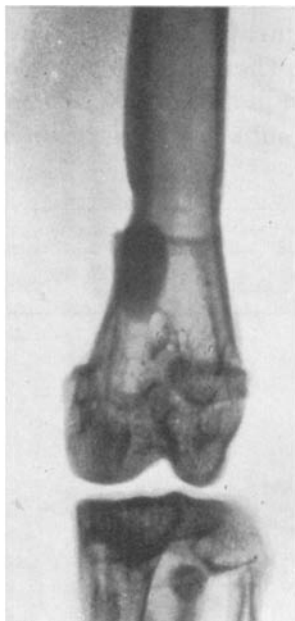


Fig. 3.

Nr. 43a. 63 days after the operation.

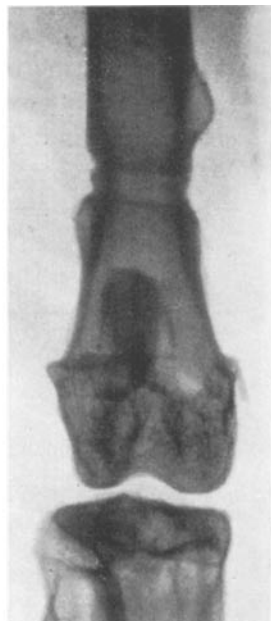


Fig. 4.

Nr. 44. 71 days after the operation.

In the second group, comprising those cases in which the catgut was not tied, the cortex had been resorbed in one case only, while in the others no definite signs of absorption could be demonstrated even after 96 days. It should, however, be mentioned that in one instance (rabbit Nr. 48) there was a vigorous periosteal reaction which might have masked a slight resorption that would otherwise have been manifest in the roentgenogram. At any rate, there was a distinct difference in the degree of resorption of the two groups.

Control experiments with knotted silk slings and metal wire showed x-ray evidence of very slight resorption after 75 days, and extremely slight resorption in the outer cortex after 104 days.

In five cases specimens of the lesioned areas were examined histologically. One of these five cases was Nr. 46, in which a spontaneous fracture occurred in the region of resorption on the 56th day after the application of the ligature. A fair amount of scar tissue was seen around the catgut. The ends of the bones were slightly roundish and macroscopically seemed to be without reaction. The catgut was found



Fig. 5.
Nr. 46. Spontaneous
fracture on 56th day.



Fig. 6.
a) Nr. 49a (catgut knotted) 104 days.
b) Nr. 49b (catgut not knotted) 154 days.

between the fractured ends. It was somewhat swollen but still knotted, intact, and still rather strong.

Microscopy of a specimen removed from rabbit Nr. 46 revealed a rather thick connective tissue capsule around the fracture but no signs of new periosteal bone formation. The lacunae in the bone were empty and therefore suggestive of necrosis, and in the cortex were numerous widened vascular spaces with signs of perivascular resorption by the connective tissue growing along the vessels. In several areas of the cortex surface there was evidence of lacunar resorption by connective tissue, and large isolated osteoclasts were observed. No signs of osteitis were discernible.

Similar though less distinctly marked changes were observed in the specimen taken from rabbit Nr. 42, but the preparation 43a presented a somewhat different picture, in that it displayed marked swelling of new-formed periosteal bone. The bone underneath the catgut was necrotic, and connective tissue had absorbed the outer layer of the cortex. In this case the reaction was much less pronounced than in the preceding one. In specimen 43b the outer layer of that region of the cortex situated underneath the catgut and consequently exposed to pressure from it, was resorbed and a number of empty lacunae and widened canals were found in the bone tissue. In preparation Nr. 50 the catgut was surrounded by young connective tissue and an initial formation of periosteal bone, but the bone was normal without signs of necrosis or resorption.

DISCUSSION

The underlying causative factors of the demonstrated bone resorption may feasibly be mechanical or histocytic, or possibly histochemical. In those experiments in which the catgut was tied around the bone the thread was drawn tight and therefore to a certain extent compressed the underlying surface of the bone. It is known from earlier research that catgut absorbs moisture from surrounding tissue and that it thereby swells considerably, particularly if it has been previously kept in highly concentrated solutions of alcohol. According to *Olesen & Jacobsen* this swelling causes an increase of 30 to 35 per cent in the diameter of the thread and *Taylor* reports 18 to 55 per cent, according to the type of catgut employed. That this swelling of the catgut will cause a considerable increase in the pressure exerted on the surface of the underlying bone will be apparent from the fact that if one ties a piece of string around a solid cylinder, the total pressure after such swelling will be 2π times the previous tension in the string (*Hultkvist*). If the thread is tied around an irregularly shaped object such as the tibia the pressure will be most marked at the edges, while the neighbouring areas will not be pressed at all. A swelling of the catgut fixed by the knot is thus capable of causing a considerable increase in the pressure on the surface, and this pressure will persist until the catgut breaks or until it is resorbed. In the case described on page 13 unabsorbed catgut was removed 6 months after the operation, and in the experiments on rabbits the catgut was intact after 56 days. This recalls the experiments undertaken by *Ritter* who found that for Nr. 2 catgut resorption took 40 to 120 days and for thicker catgut a longer time. A factor counteracting the increase in pressure

due to swelling of the catgut is the increase in the stretching potential of the latter when wet (cf. *Taylor*).

In those experiments in which the catgut was tied and thus capable of compressing the bone, the bone resorption was greater than when the catgut was not tied. Of the latter cases roentgenography showed a fair amount of resorption in one instance and slight possible resorption in another. Here the resorption ought not to be attributed to pressure but to a tissue reaction, possibly also to granulation tissue that had formed around the thread. As mentioned before *Lexer*, *Koelsch* and others assume a reaction of this type to be the cause of bone resorption and poor callus formation when catgut is used. *Localido* and others observed in rats that in those animals whose scars were sutured with catgut the inflammatory reaction was livelier and more persistent, with consequently retarded maturity of the fibroblast and collagen formation; besides this, tendency to necrosis was more pronounced than when silk, cotton, nylon etc. were used. Hence, it can hardly be denied that catgut may in itself cause a specific inflammation over and above the ordinary foreign body reaction.

Histologic examination of part of the material revealed a fairly rich formation of connective tissue around the catgut and that the resorption of the bone—which was also necrotic—was due to a lacunar or vascular process. Giant cells were sparse and no obvious increase in exudative cells was observed in the preparations either. In preparation 50, in which the catgut had not been tied, there was evidence of considerable connective tissue reaction after 18 days but no signs of resorption or necrosis of the bone.

The experimentally demonstrated resorption of the bone by catgut may therefore probably be explained by a certain tissue reaction to the catgut, but particularly by the pressure it exercises on the bone. These observations will also probably help to explain the difference in the results reported by earlier workers. *Lexer* and *Koelsch*, for example, observed increased tissue reaction and resorption in their experiments, in which there must have been a certain amount of tension in the catgut, while *Dahl-Iversen* tied the catgut ribbons over horn grafts so that certain parts of the surrounding bone were not submitted to such pressure.

The present experiments therefore showed that catgut should not be used in osteosynthesis, at least not in the form of a cerclage because of the risk of local bone resorption, which will not only prolong the healing course but also reduce the local resistance of the bone, which may then fracture. In cases of resection with end to end fixation, when the fragments are often fastened together by means of a thread

drawn through holes drilled in the ends of the bone, the use of catgut will also incur the risk of a certain untoward reaction. The holes bored tend to be widened by the pressure exercised when the catgut is drawn tight and, if the holes are near the end of a fragment, it is liable to cut through the latter.

S U M M A R Y

On account of a case in which catgut was used in the osteosynthesis of a fracture of the lower leg and in which there later developed a marked, persistent (about 6 months) bone resorption, the author performed a number of animal experiments. It was shown on the basis of these experiments that if catgut is tied around the femur of a rabbit, severe bone resorption, which may even lead to spontaneous fracture will develop within one to two months. If the catgut is not knotted, it will cause but slight or no bone resorption. The resorption is assumed to be due to the pressure arising from the swelling of the catgut which causes local bone necrosis and lacunar resorption.

R E S U M E

A la suite d'un cas dans lequel on avait utilisé un cerclage de catgut pour la fixation d'une fracture de la partie inférieure de la jambe et chez lequel il était apparu au bout d'une longue période (six mois env.) une résorption osseuse, l'auteur a procédé à un certain nombre d'essais sur animaux. Ceux-ci ont prouvé que si l'on attache un fil de catgut autour du fémur d'un lapin, il se produit dans l'espace d'un ou deux mois une forte résorption osseuse qui peut même conduire à une fracture spontanée. Lorsque le fil de catgut n'est pas attaché, il n'y a par contre pas de résorption osseuse ou en tout cas celle-ci est insignifiante. Il est à supposer que la cause de la résorption est imputable à la pression de l'enflure causée par le catgut provoquant une nécrose locale et une destruction partielle de l'os.

Z U S A M M E N F A S S U N G

Im Anschluss daran, dass ein Fall, in welchem Catgutcerclage zur Fixation eines Unterschenkelbruches angewendet wurde, im postoperativen Verlauf eine deutliche und lange Zeit hindurch (ungefähr 6 Monate) bestehende Knochenresorption zeigte, hat der Verfasser einige Tierversuche vorgenommen. Mittels dieser konnte er vorweisen dass im Verlaufe von ein bis zwei Monaten eine deutliche Knochen-

resorption auftritt, wenn man einen Catgutfaden um den Oberschenkelknochen eines Kaninchens bindet und dass diese sogar zur Spontanfraktur führen kann. Wenn man den Catgutfaden nicht bindet erhält man keine oder doch nur unbedeutende Knochenresorption. Als Ursache der Resorption sieht man den Schwellungsdruck des Catguts an, der eine örtliche Knochennekrose und eine lakunäre Knochenauflösung hervorruft.

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