

Long-Term Comparative Study of Nonabsorbable Sutures

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AFTER most surgical operations when the wound has gained sufficient maturity and tensile strength, sutures have no further function and ideally are absorbed. However, with some operations, particularly cardiovascular,^{4,5} there is limited connective tissue response and the coherence of the sutured structures depends on the continued integrity of the sutures. At the same time, a bland tissue reaction is desirable and less likely to cause late complications. For these reasons, changes in the tensile strength of nonabsorbable sutures and the tissue reaction produced is of importance.

In our previous studies of nonabsorbable sutures,¹ the observations were terminated after 6 weeks, when the tensile strength was well maintained and the tissue reaction markedly decreased. Subsequently, silk was used as a control of absorbable sutures in implantation studies which ended in 8 months.² The tissue reaction to silk was much greater than anticipated. For this reason, an implantation experiment to extend for 2 years was initiated.

Methods

Suture materials investigated were silk, cotton, monofilament nylon, monofilament polypropylene, multifilament dacron (Mersilene) and two types of dacron coated with teflon (Polydek and Tevdek). Size 000 was used. Loops of the sutures were implanted in the abdominal wall muscles

of rabbits, using the same technic previously described, illustrated in Figure 1. The animals were sacrificed at the following intervals: 1, 2, and 4 weeks; 3, 6, 12, 18, and 24 months. From 12 to 15 animals were operated upon for each time interval; from 7 to 15 survived the appropriate time. Seven animals were sacrificed in 2 weeks, seven at 24 months, nine each at 4 weeks, 3 and 6 months, 13 each at 12 and 18 months, and 15 at 1 week.

Tissue to obtain a cross section of the implanted sutures was removed for fixation and hematoxylin and eosin stain. Reaction to the suture was graded by a histologic scoring system based on the criteria described by Sewell, Wiland and Craver.³ These are essentially the size of the reaction zone about the suture and the type and number of cells therein. The remaining portion of the suture loop was removed and the tensile strength determined on a locally constructed tensiometer. From 7 to 60 sutures were graded per suture per time interval, averaging 29. Approximately the same number of tensile strength tests were made except for silk and cotton sutures at the longer intervals.

Results

The numerical results are shown in the tables and figures.

The tissue reaction to silk after one week consists essentially of granulation tissue with a peripheral rim of connective tissue which is variable in extent and maturity. The predominant cells are histiocytes and fibroblasts. Occasional capillaries are seen

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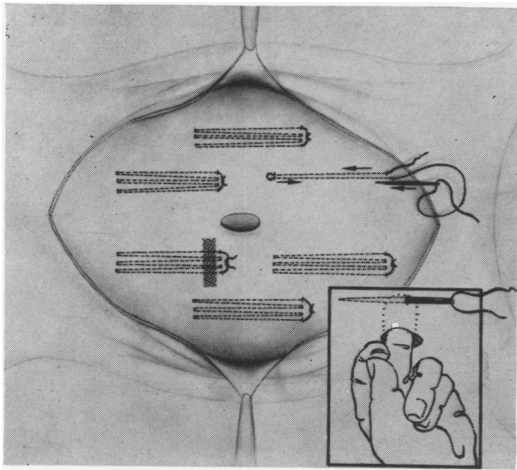


FIG. 1. Method of implantation of sutures. Long incision exposing abdominal wall muscles. Incision into peritoneum in midportion through which finger is inserted to protect bowel during placement of suture loops. Stippled area is block of tissue removed for histologic study.

and a few lymphocytes and neutrophiles. Later, at 2 and 4 weeks, capillaries are few, the histiocytes less densely packed, neutrophils scarce, and fibrous tissue increased. This progression continues at 3 months and at 6 months. At 3 months the first disappearance of silk fibers is observed. In the 12, 18 and 24 month specimens, a firm fibrous tissue capsule is usually found but histiocytes and some lymphocytes are still present. The mononuclear response is variable and, in some sections, fairly marked. A few sutures are found in which only a small number of strands remain. These may be embedded in fibrous tissue or surrounded by histiocytes. Giant cells are occasionally seen at all time intervals. The general tendency is for the silk suture to remain a compact bundle. Occasionally,

TABLE 1. Average Tensile Strength of Sutures (Grams)

	Silk	Cotton	Nylon	Polypropylene	Dacron	Polydek	Tevdek
Weeks							
1	1,442	1,236	1,823	1,755	2,216	2,413	2,423
2	1,253	1,211	1,791	1,850	2,035	2,685	3,382
4	844	1,322	1,764	1,975	2,291	2,772	3,325
Months							
3	293	825	1,605	1,802	2,013	2,495	3,177
6	516	647	1,433	1,634	1,542	1,875	2,203
12	833	618	1,628	1,711	1,992	2,394	2,324
18	481	482	1,295	1,693	1,955	2,223	2,444
24	0	712	1,314	1,744	2,119	2,787	2,110

TABLE 2. Average Grade of Tissue Reaction

	Silk	Cotton	Nylon	Polypropylene	Dacron	Polydek	Tevdek
Weeks							
1	43.9	47.9	37.5	38.2	39.9	40.6	39.9
2	44.1	48.6	32.8	33.3	31.6	32.2	39.4
4	44.9	45.7	28.8	32.2	29.9	37.8	40.6
Months							
3	38.1	38.6	24.4	19.3	25.4	29.0	40.2
6	35.0	38.9	17.6	20.3	24.6	36.5	35.4
12	32.7	32.6	12.6	22.3	22.2	27.7	22.7
18	31.7	34.5	13.5	15.8	18.8	30.6	30.5
24	33.1	35.4	13.4	21.3	20.2	33.1	25.5

(The lowest grade attainable is 9.)

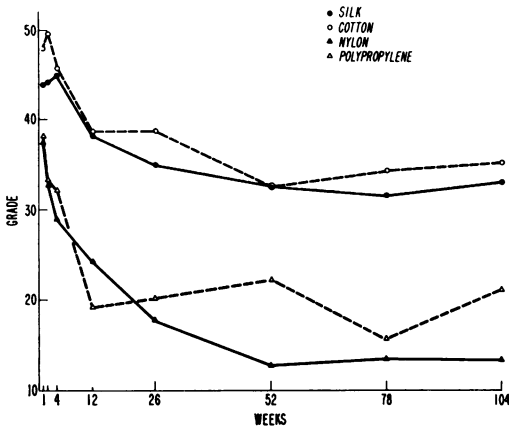


FIG. 2. Silk and cotton consistently show more tissue reaction than the synthetic sutures.

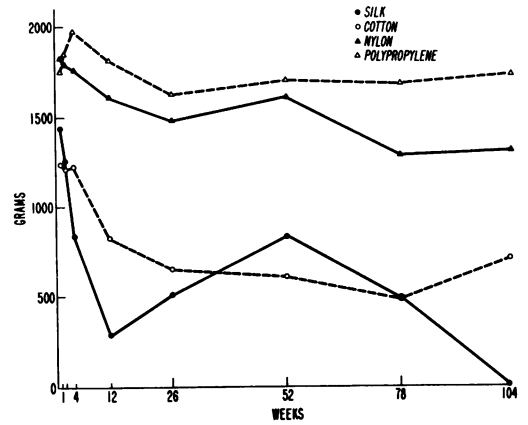


FIG. 4. Polypropylene maintains tensile strength throughout the 2 year period. The silk curve is erratic (see text).

cellular and fibrous tissue is seen to invade between the strands.

The early reaction to cotton is similar to that to silk but the overall cellular reaction is a little greater. At the end of 4 weeks, increased amounts of fibrous tissue are evident but granulation tissue is still present. Foreign body giant cells are more prominent than with silk. At 3 and 6 months the fibrous tissue capsule is more noticeable but the cellular reaction is appreciable. After a year, the tendency toward more connective tissue and less cellular reaction continues but the latter is marked around some sutures. This is particularly true when cotton fibers begin to migrate from the

main mass of suture, as each fiber seems to stimulate its own reaction. The specimens at 18 months show most sutures encased in fibrous tissue with a variable amount of histiocytic and lymphocyte infiltration next to the suture. Again, those with separation of the fibers show a much more marked reaction. At two years there is no particular difference; the separation of the fibers and the resultant response accounts for the relatively high grading at these later intervals.

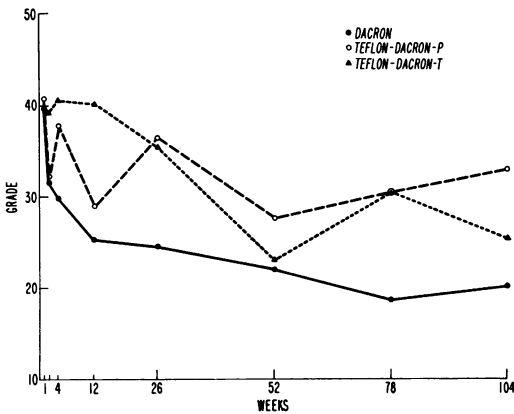


FIG. 3. The teflon coating is shed, causing an increased tissue reaction over plain dacron.

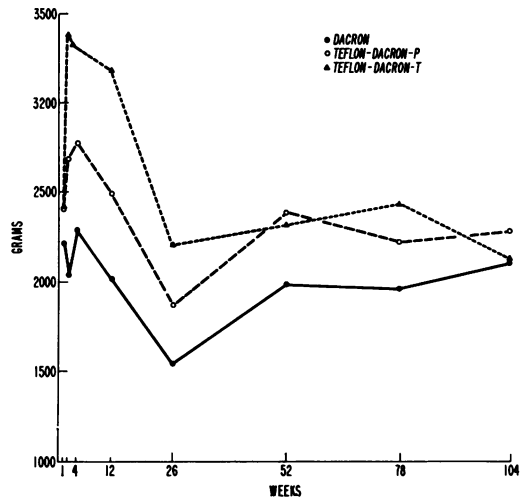


FIG. 5. Dacron maintains tensile strength well. No explanation is apparent for the temporary increase in tensile strength.

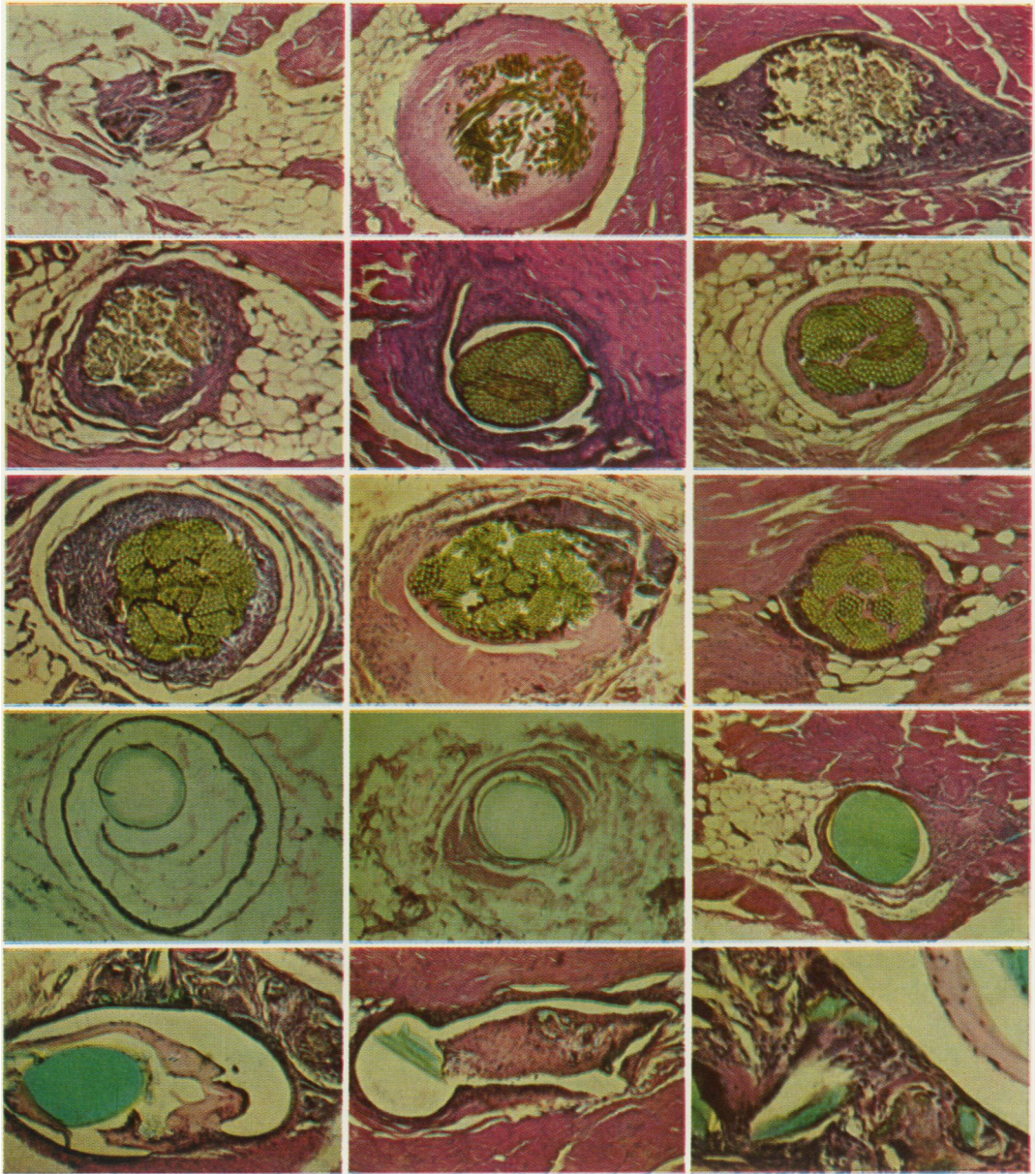


FIG. 6. (A-C, top row, left to right) A. Silk almost completely absorbed after 6 months. B. Silk after 2 years imbedded in firm fibrous tissue. C. Cotton after 4 weeks shows individual fibers separated from main mass of suture. (D-F, 2nd row from top) D. Cotton after 6 months with considerable mononuclear response continuing. E. Dacron in 1 week shows response typical for all sutures at this interval. F. Dacron after 18 months shows almost no reaction except fibrous tissue. (G-I, center row) G. Tevdek after 12 weeks with reaction secondary to shed teflon. H. Tevdek in 18 months teflon fragments only in right upper portion of reaction zone. I. Little reaction to Tevdek at 2 years. (J-L, 2nd row from bottom) J. Nylon surrounded by open zone at 18 months. K. Nylon showing rim of fibrous tissue after 2 years. L. Polypropylene with little reaction after 6 months. (M-O, bottom row) M. Polypropylene with some fragmentation after 18 months. N. Same at 2 years. O. Higher power of edge of polypropylene suture and fragments.

The dacron material in the early weeks results in less cellular reaction and more fibrous tissue as compared with silk and cotton. Neutrophils are fewer and the histiocytic reaction is in the area adjacent to the suture. By 3 months, sutures are seen more frequently with a rim of connective tissue and with only one or two layers of histiocytes next to the suture. Rarely giant cells are present. The picture changes gradually at 6 and 12 months with fewer histiocytes and by a year, most sutures are tightly encased in fibrous tissue with little cellular reaction. At 18 and 24 months, only a minimal number of histiocytes are seen. The sutures remain compact.

Nylon in the first week stimulates the usual cellular response which is less severe. Histiocytes and fibroblasts predominate, with a few lymphocytes and neutrophils. At 2 weeks, some sutures show clear zones around the suture, containing a number of unattached cells which are mainly histiocytes. In four weeks, a similar response is seen although some sutures show a tight rim of connective tissue. After 6 and 12 months, the cellular reaction is minimal. Most sutures are firmly encased in a thin scar; a few have the wide clear zone. Little change occurs through the 2-year period. The grade of the reaction is the least of sutures studied and would be even less except for the few sutures in which clear zones persist.

The reaction to polypropylene is similar to that of nylon although generally a little more cellular through all time intervals. These sutures also occasionally have large clear zones. At 18 months and even more often at 2 years an occasional suture has started to fragment. The entire suture does not break up but small portions appear to separate from one edge. Each minute fragment, although remaining in the vicinity, stimulates its own cellular reaction. This, of course, increases the grade of the tissue reaction so that it exceeds nylon.

The two teflon treated dacron sutures

can be considered together as the reactions are so similar. Both stimulate the usual early response, although this is less than that to silk or cotton. At 2 weeks, occasional shedding of the teflon is seen; this is more marked at 1, 3 and 6 months. As long as no shedding occurs, the reaction is mainly a fibrous tissue capsule. With shedding, however, each fragment stimulates a cellular reaction which is frequently intense. Infrequently, the fragments are seen a considerable distance from the suture, particularly after a year. At 18 and 24 months, a few sutures are found which have apparently shed all of the teflon as the appearance is that of a compact dacron suture surrounded by a thin rim of scar tissue.

The tensile strength determinations show that synthetic sutures lose little or no strength over a 2-year period. The erratic tensile strength curves obtained with silk and cotton are notable and will be discussed below.

Discussion

It is apparent that silk is slowly absorbed although the rate is quite variable. A completely intact suture histologically may be seen after 2 years' implantation, but others show a definite decrease in the number of fibers. Although occasionally little cellular reaction is present, a histiocytic response is usually seen. Cotton shows no evidence of disappearance. The reaction is sustained mainly because of individual fibers separating from the main mass. Infrequently a comparatively massive reaction, mainly histiocytic, occurs when all of the cotton fibers are separated.

The monofilament sutures cause the least reaction but the large clear spaces around some of them were of interest. Apparently the movement of the abdominal wall causes the rigid suture to act as a dilator to stretch the scar and form a tube about the suture. The fragmentation of polypropylene is in contrast to the nylon which remains intact.

In correspondence with the manufacturer, it was learned that these sutures were the first extruded from their first shipment of polypropylene. Subsequently, changes have been made to improve the extrusion process and it is believed that fragmentation will not occur with the presently available sutures. Additional long-term studies have been initiated however. Parenthetically, the polypropylene did retain tensile strength.

Dacron causes little reaction. Those sutures treated with teflon have an increased amount of tissue reaction because of the dislodged fragments of teflon. The differences are not major and may not be of clinical significance but increased reaction occurs. Exactly what happens to the teflon is not demonstrated in our studies.

The tensile strength changes require no comment other than silk and cotton. After 4 weeks, some silk sutures and to a lesser degree cotton, had lost tensile strength to the point where the suture could not be pulled from the tissue without breaking. This was more frequent with each time increment. The sutures which could be removed for tensile strength determinations therefore were obviously the stronger sutures and the averages in the table are based on these sutures. As this much difference in the sutures seems unlikely, one can only assume biologic variation as the cause which is, of course, an unsatisfactory and incomplete explanation. The possibility does exist, however, that the components of the tissues causing digestion of the suture vary from animal to animal and that this variation is real.

DISCUSSION

DR. JOSEPH M. MILLER (Fort Howard): This opportunity to discuss the report of Dr. Postlethwait is a privilege because it is but one in an excellent series about the relation of sutures to wound healing which he has conducted. Review of the work on tissue repair and regeneration

As noted, another study of nonabsorbable sutures has been started with the object of extending the time considerably beyond two years.

Summary

Silk, cotton, dacron, nylon and polypropylene sutures were implanted in the abdominal wall muscles of rabbits. Tensile strength determinations and tissue reactions were graded at intervals up to 2 years. Silk and cotton gradually lost tensile strength; silk was absorbed at a variable rate. Nylon showed a moderate decrease in tensile strength but caused the least tissue reaction. Polypropylene maintained its tensile strength and showed low tissue reaction until the late intervals when slight fragmentation of a few sutures occurred. The dacron maintained tensile strength and caused a moderate tissue reaction.

References

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suggests that three overlapping historical periods may be delineated. The first is the time of digestion from released cellular enzymes; the second is initiated by the appearance of the fibroblast, the production of collagen, and its extracellular extrusion; and, in the third, the intramolecular and then the intermolecular bonding of the collagen mole-