Influence of Different Types of Non-resorbable Suture Material on the Healing of Extraction Wounds

—A Histological Study in Rats—

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Abstract

The influence of different non-resorbable suture materials on the healing of tooth extraction wounds was examined in 120 adult male albino rats. Nylon gave the best biological results for healing of the mucosa and dental socket. Silk and cotton produced considerable delay of socket healing. Healing was only mildly delayed by polyester suture, with a short moderate inflammatory reaction at the initial stage.

Introduction

The process of healing of tooth extraction wounds does not basically differ from that of healing of connective tissues in other regions. However, it shows some local characteristics, such as the type of tissue reaction initiated inside the dental socket soon after tooth removal, eventually producing newly formed osseous trabeculae capable of resisting the pressure created by masticatory effort.

Several local factors may influence the timing of this healing process, among which suturing plays a role. The influence of suture material on extraction wounds has been clearly observed in experimental studies. Absence of suturing considerably delays the healing process¹¹, and some suture materials may influence cell proliferation. Thus, the suture material should be biocompatible in order to produce a shorter and less intense inflammatory phase, at least during the exudative phase of inflammation²².

Several intra- and extraoral studies have shown the superiority of synthetic suture materials in relation to biocompatibility³³–⁹⁹. Threaded cotton suture is still used widely for intraoral stitching in this country, especially because of its easy manipulation and sterilization⁴⁴. This is a multifilament, twisted suture that greatly influences intraoral tissue repair. It

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produces extensive areas of severe inflammation and tends to retain a lot of residue\(^{10}\).

Threaded silk in superficial and deep sutures has demonstrated some advantages over cotton suture. This is also a twisted multifilament suture, producing a less severe inflammatory reaction around the stitches\(^{3,8,11}\), as compared with cotton.

Polyester in superficial and deep sutures produces a shorter and milder inflammatory reaction\(^{1,4}\). It is also a multifilament stretched suture. This is a non-resorbable material, and foreign body reaction has been observed in deep sutures\(^{1}\).

Among the synthetic suture materials, nylon undoubtedly produces the mildest tissue reaction\(^{1,11}\). This is also a non-resorbable monofilament suture, and is widely used in sites where esthetics are important. Fibroblastic and capillary proliferation related to this type of material occurs earlier in comparison with the other kinds.

This brief review of the literature shows that the available information on suture materials deals largely with the gingival mucosa and skin. Previous studies have shown that prolongation of the mucosal inflammatory phase interferes markedly with dental socket healing\(^{7}\). Considering that tooth extraction is the most widely performed procedure in oral surgery, the present study was designed to test the influence of different non-resorbable suture materials on healing of the gingival mucosa and dental sockets after tooth extraction.

**Materials and Methods**

One hundred and twenty male adult albino rats (\*Rattus norve gicus, albinus\*, Wistar), weighing between 160 and 200 g were used in the present study. The animals, before and during the experiment, were fed with a balanced diet (Ração Ativada Produtor, Anderson Clayton, S. A.), except for the first 24 h after surgery, and water *ad libitum*.

Under general anesthesia by intraperitoneal infiltration of thionembutal (50 mg/kg), the upper right incisor was extracted as described elsewhere\(^{12}\).

The animals were divided into four groups as follows, according to the suture material (Ethicon) employed for closure of the gingival mucosa:

- **Group I** — 4-0 cotton suture
- **Group II** — 4-0 silk suture
- **Group III** — 4-0 polyester suture
- **Group IV** — 4-0 nylon suture

In all animals, the mucosa was sutured with a single stitch, joining the borders of the wound.

Six animals in each experimental group were sacrificed by sulfuric ether inhalation 3, 6, 9, 15 and 21 days after the operation. The maxilla was then divided sagittally, obtaining a specimen including the whole right incisor socket. The specimens were fixed in a 10% formalin solution and decalcified in a 50% sodium citrate/formic acid solution\(^{13}\), following routine laboratory procedures. The blocks were cut semi-serially into 6-\(\mu\)m thick sections, then stained with hematox-
ylin/eosin for histological analysis.

Results

The results are described for each of the experimental periods considered:

1. GINGIVAL MUCOSA

3 days

a) Cotton—In two specimens, discrete basal proliferation was observed in the gingival mucosa epithelium. In the remaining specimens, an intense neutrophilic infiltrate could be seen close to the suture material (Fig. 1), as well as absence of epithelial proliferation. Large numbers of cells in different stages of degeneration were also observed.

b) Silk—All specimens exhibited discrete proliferation of the gingival mucosa epithelium. The adjacent connective tissue showed fewer neutrophils in comparison with the previous group (Fig. 2). Lymphocytes and macrophages were present in varying numbers.

c) Polyester—The proliferation of the gingival mucosa epithelium was more intense than that in the silk group. The adjacent connective tissue contained discrete inflammatory infiltrates, mainly lymphocytes. Proliferation of fibroblasts and blood vessels was only moderate (Fig. 3).

d) Nylon—Epithelial proliferation was intense in all specimens (Fig. 4). Organized connective tissue was noted close to the suture material. In some cases, occasional lymphocytes were seen in the adjacent connective tissue.

6 days

a) Cotton—Moderate proliferation of the gingival mucosa epithelium was noted, but an extensive continuity defect persisted. The inflammatory infiltrate was still intense in the area adjacent to the epithelium, with predominance of neutrophils.

b) Silk—Epithelial proliferation was moderate in all specimens, only partly occluding the socket. The inflammatory infiltrate was intense in some specimens and moderate to discrete in others with predominance of lymphocytes.

c) Polyester—The epithelium partly covered the socket. In all specimens, the inflammatory infiltrate was more pronounced than in the previous group. In the adjacent connective tissue, lymphocytes were noted.

d) Nylon—The epithelium covered the socket in two cases. In the remaining specimens, about 2/3 of the socket was covered. The adjacent connective tissue was well vascularized and rich in fibroblasts in all specimens. A number of discrete lymphocytes were observed.

9 days

a) Cotton—The epithelium of the gingival mucosa, except for 1 case, totally covered the socket. However, the adjacent connective tissue was poorly differentiated, showing inflammatory infiltration by numerous lymphocytes and macrophages, in all specimens.

b) Silk—In all specimens, the epithelium totally covered the sockets and showed better defined characteristics than in the previous (cotton) group. The adjacent connective tissue exhibited numerous lymphocytes.

c) Polyester—The gingival epithelium totally covered the dental socket, and the
adjacent connective tissue was well organized. Some lymphocytes were evident.

d) Nylon—The morphological characteristics were comparable to those seen in
the previous group. However, in some cases, the epithelium was better differentiated.

For the 15- and 21-day periods, all specimens in all groups showed a well
defined epithelium which totally covered the dental socket.

2. DENTAL ALVEOLUS

3 days

a) Cotton—The dental alveolus was filled with clotted blood. Numerous macro-
phages were seen, exhibiting cytoplasmic hemosiderin pigmentation. Close to the
bone wall, in the middle and apical thirds, rests of periodontal ligament were
observed. The ligament was well vascularized and rich in fibroblasts. In most cases,
a number of fibroblasts and newly formed capillaries were present close to the
middle and apical thirds on the palatine side. At the level of the cervical third,
however, this connective tissue was less evident and numerous neutrophils were
seen, especially close to the most cervical portion of the socket. In some specimens,
resorption of the lingual bone wall was evident in the cervical third.

b) Silk—The morphological features at the middle and apical thirds were
comparable to those observed in the previous (cotton) group. However, at the
cervical third, the inflammatory infiltrate was less pronounced, with a moderate
number of neutrophils. In most specimens, fibroblastic and capillary proliferation
was more pronounced at the middle and apical thirds.

c) Polyester—At the level of the cervical third, the dental alveolus showed
moderate inflammatory infiltration, characterized by the presence of neutrophils.
However, close to the free margin, the infiltrate was less pronounced in relation to
the previous (silk) group. On the other hand, at the level of the middle and apical
thirds, a great number of newly formed fibroblasts and capillaries were noted.

b) Nylon—The inflammatory infiltrate at the cervical third was pronounced in
all specimens, and characterized by the presence of lymphocytes. However, at the
level of the middle and apical thirds, this group differed from the others by the
presence of a great number of fibroblasts and newly formed capillaries, especially
in areas close to the lingual wall. In some cases, a small amount of amorphous
matrix was seen.

6 days

a) Cotton—The inflammatory infiltrate persisted in the cervical third, mainly
consisting of numerous neutrophils or lymphocytes, as well as macrophages. On
the other hand, the lingual bone wall in this region showed resorption and
numerous osteoclasts (Fig. 5). At the level of the middle and apical thirds, small
amounts of newly formed and well vascularized connective tissue were found,
which were rich in fibroblasts. However, at least half of the socket was filled with
residual clotted blood with a great number of macrophages.

b) Silk—In all specimens, a moderate number of lymphocytes and macrophages
were observed close to the cervical third. The lingual bone wall at this level
showed moderate osteoclastic resorption (Fig. 6). At the level of the middle and
apical thirds, mainly close to the lingual bone, well vascularized connective tissue
rich in fibroblasts was evident, filling about half of the socket. In some cases small
newly formed bone particles were noted. In the remaining area, the socket was filled with clotted blood showing the same characteristics as those observed in the previous group.

c) Polyester—In some cases, the alveolar bone wall close to the cervical third showed discrete resorption with the presence of osteoclasts. A number of fibroblasts could be seen invading the blood clot (Fig. 7). At the level of the middle and apical thirds, and also in part of the cervical third, a great amount of newly formed connective tissue, rich in fibroblasts, was found. Fine bone trabeculae were observed close to the alveolar bone wall. In several areas, however, residual clotted blood was present.

d) Nylon—Throughout the whole socket, newly formed well vascularized connective tissue was observed, rich in fibroblasts (Fig. 8). At the level of the middle and apical thirds, newly formed osseous trabeculae were seen close to the alveolar bone wall. In some cases the trabeculae filled more extensive areas than those observed in the previous (polyester) group. At several points, residual blood clots were found.

9 days

a) Cotton—The middle and apical thirds were partly filled with newly formed, usually thin, osseous trabeculae. The newly formed bone was most evident close to the alveolar wall, associated with intense osteoblastic activity. Closer to the central portion of the socket as well as the cervical third, connective tissue was found, without bone differentiation. Also in the cervical third, a moderate number of lymphocytes were present. At some points, disorganized blood clots were found.

b) Silk—Fine newly formed bone trabeculae partly filled the socket at the level of the middle and apical thirds. However, there were more newly formed trabeculae than in the previous group. Areas further away from the bone walls, and also at the level of the cervical third, contained connective tissue without bone differentiation. At some points, residual disorganized blood clots were found.

c) Polyester—The three alveolar thirds were filled with newly formed connective tissue. At the level of the middle and apical thirds and adjacent to the bone walls at the cervical third, fine bone trabeculae were observed. When compared to the previous (silk) group, however, the trabeculae were generally better developed and more regular. In some cases, thick trabeculae were found adjacent to the alveolar wall at the middle third. As in the previous group, residual clotted blood was present.

d) Nylon—Along the three alveolar thirds, newly formed bone trabeculae were evident. These trabeculae were generally thin with ample medullary spaces. However, in several instances, close to the bone wall of the apical and middle thirds, the trabeculae were thick. This group was different from the previous ones in that newly formed bone was present in the whole cervical third, although the trabeculae were still thin and irregular.

15 days

a) Cotton—At the level of the middle and apical thirds, newly formed osseous trabeculae were noted, usually close to the alveolar wall. However, these trabeculae occupied only part of the alveolus. Areas further away from the alveolar
walls displayed connective tissue without bone differentiation. Occasionally, residual blood clots were seen.
b) Silk—The middle and apical thirds showed thick and well defined trabeculae, especially close to the alveolar walls. In several instances, closer to the center of the socket, the bone was less well defined, with ample medullary spaces. Close to the cervical third, small thin trabeculae were seen only in the proximity with the alveolar wall. At some points, residual blood clots were seen.
c) Polyester—The whole socket contained newly formed trabeculae. At the middle and apical thirds, the osseous tissue was well organized with well defined medullary channels. However, close to the cervical third, the trabeculae were thin with large medullary spaces. Occasionally, small areas of disorganized blood clots were seen.
d) Nylon—The morphological characteristics were comparable to those observed for the previous (polyester) group, especially in areas close to the middle and apical thirds. However, at the level of the cervical third, most cases showed more intense ossification, with thick trabeculae close to the alveolar wall.

21 days
a) Cotton—The apical and middle thirds were filled by osseous trabeculae, which were usually thick and well organized. Occasionally, areas of immature bone with ample medullary spaces were found. Close to the cervical third, however, the newly formed bone only partly filled the socket, leaving large spaces filled with connective tissue without bone differentiation (Fig. 9).
b) Silk—The middle and apical thirds were occupied by thick and well defined bone trabeculae. Adjacent to the cervical third, however, well developed bone was seen only in association with the alveolar walls (Fig. 10). In the more central areas, a large amount of connective tissue without bone differentiation was found.
c) Polyester—The three alveolar thirds were filled with newly formed bone. However, adjacent to the cervical third, although the trabeculae regularly filled the whole socket, they were thin and poorly defined with large medullary spaces (Fig. 11).
d) Nylon—The whole socket was filled by thick and well defined bone trabeculae, including the cervical third (Fig. 12).

Discussion

The healing of the gingival mucosa may be divided into two distinct phases: the “exudative or latent phase”[^2^], which is characterized by the presence of neutrophils, cell lysis and exudative absorption, and the “reparative” or “proliferative” phase, characterized by the presence of connective tissue cells, mainly fibroblasts and undifferentiated mesenchymal cells[^9^]. Therefore it would be expected that local factors, such as suture materials, which interfere with healing, especially in the exudative phase, would also affect the healing of the socket.

In the present study, cotton suture produced a more intense and prolonged inflammatory reaction. As a consequence, intense resorption of the cervical alveolar walls and considerable delay in the process of socket healing occurred in all specimens. This kind of inflammatory response is probably due to the great
capillarity of the cotton thread, facilitating the accumulation of secretions, which are effective culture media for the development of microorganisms\[^4,8,14\].

Silk showed a better effect, although an intense inflammatory response was noted at the initial stage. The resorption of the alveolar walls was less pronounced and the delay in the process of alveolar healing was shorter. CARIDE et al.\[^3\] found silk superior to cotton when implanted in the oral mucosa of rats. Earlier epithelial and connective tissue proliferation was also observed in a previous study\[^8\].

On the other hand, the gingival mucosa sutured with polyester thread showed a short exudative phase with minimal delay of the proliferative phase. The biocompatibility of polyester suture was also observed by CASTRO et al.\[^4\], who reported intense cell proliferation three days after extraction, both closer and further away from the material. The marked infiltration at the gingival level observed in this study indicated a better environment for the initiation of socket healing. This was confirmed by the absence of alveolar wall resorption and preservation of the periodontal ligament at the cervical level, which did not occur with cotton and silk, materials which delayed the process of healing of the dental socket.

Among the materials tested in the present study, nylon gave the best results from the standpoint of biocompatibility, as expected from previous studies on the healing of soft tissues\[^1,5,6,11,15\]. The same was true for the dental alveolus, where the favorable reaction to the material allowed earlier and more intense connective tissue proliferation at the level of the cervical third, in comparison with the other groups. Nylon has a monofilament structure and thus lacks capillarity, virtually eliminating the absorption of oral fluids.

Cotton thread, although a limited material in comparison with synthetic suture materials, still has its place in this country because of its low cost, being used for mucosal suturing after exodontia. However, in more delicate procedures or when sutures must stay in place for over 3 days, other materials such as polyester should be chosen. Also, patients with systemic conditions that may alter the healing process will probably show more favorable healing with different materials. Silk offers no great biological advantages over cotton, and the mounted threads available commercially are not superior from the standpoint of cost and effect.

Polyester thread offers an alternative to cotton when cost and biological efficacy are an issue. It may also be used for more delicate oral surgery and periodontal procedures. Nylon is the best material from a biological standpoint. However, it is stiffer than the other materials and may be uncomfortable for the patient when used for interrupted sutures in some intraoral sites. Furthermore, it is usually more difficult to remove when used intraorally.

Conclusions

Within the methodology used in the present study, it is possible to conclude that:

1) Suturing of the gingival mucosa with cotton thread promotes an intense inflammatory reaction, considerably delaying the process of healing of
extraction wounds.

2) Nylon presents the least inflammatory reaction and allows more favorable alveolar healing.

3) Polyester produces a short moderate inflammatory reaction, with a short delay in alveolar healing when compared to nylon.

4) Silk produces an intense inflammatory reaction in the initial stages, but is less pronounced than that observed for cotton.

5) Cotton, although a limited material in comparison with synthetic ones, may be employed for mucosal sutures after exodontia, due to its low cost. Its use, however, is best avoided in patients with systemic conditions that compromise healing.

References


Fig. 1  3 days. Cotton. Epithelium without evidence of proliferation. Intense inflammatory infiltrate in the adjacent connective tissue. H. E. x160.

Fig. 2  3 days. Silk. Discrete proliferation of the gingival mucosal epithelium. Moderate inflammatory infiltration is evident in the adjacent connective tissue. H. E. x160.

Fig. 3  3 days. Polyester. More pronounced epithelial proliferation in comparison with the previous group (silk). Discrete inflammatory infiltrate is evident in the adjacent connective tissue.
Fig. 4  3 days. Nylon. Intense epithelial proliferation. Inflammatory infiltration is absent and several fibroblasts can be seen. H. E. x160.

Fig. 5  6 days. Cotton. Cervical third close to the socket opening, exhibiting intense osteoclastic resorption of the alveolar bone wall. Intense inflammatory infiltration is also noted. H. E. x63.

Fig. 6  Silk. Area similar to that shown in the previous figure. Moderate resorption of the bone wall, with the presence of osteoclasts. Moderate inflammatory infiltrate can be seen. H. E. x63.
Fig. 7  
6 days. Polyester. Area similar to that in Fig. 6, showing absence of bone resorption and preservation of the periodontal ligament. Discrete proliferation of newly formed fibroblasts and capillaries is evident. H. E. x63.

Fig. 8  
6 days. Nylon. Area similar to that shown in Fig. 6. The bone wall is intact and exhibits intense proliferation of fibroblasts and capillaries, close to the remaining periodontal ligament. H. E. x63.

Fig. 9  
21 days. Cotton. Cervical third close to the alveolar opening. Discrete ossification with a large amount of connective tissue is evident without bone differentiation. H. E. x23.
Fig. 10 21 days. Silk. Area similar to that shown in the previous figure, with thin bone trabeculae filling about 1/3 of the cervical portion of the socket. H. E. x23.

Fig. 11 21 days. Polyester. Area similar to that shown in Fig. 10. Poorly differentiated bone trabeculae fill about 1/2 of the cervical third of the alveolus. H. E. x23.

Fig. 12 21 days. Nylon. Area similar to that shown in Fig. 11. More differentiated bone trabeculae fill almost the whole cervical third of the socket. H. E. x23.