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Tissue reactions to sutures in the presence and absence of anti-infective therapy

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Abstract

Background: In the oral cavity, sutures are placed within tissues of high vascularity in a moist environment with infectious potential. The objective of this study was to evaluate tissue reactions at silk and expanded polytetrafluoroethylene (ePTFE) sutures in the presence and absence of anti-infective therapy (AT).

Methods: Thirty-six sutures were placed within the mandibular keratinized gingiva in six Beagle dogs. Each animal received one braided silk (4-0) and one ePTFE (CV-5) suture in contra-lateral jaw quadrants at 14, 7, and 3 days prior to biopsy. Three animals received daily AT including topical 2% chlorhexidine solution and a systemic broad-spectrum antibiotic. Biopsy specimens allowed histometric analysis of tissue reactions along the central part of the suture loop including the area of perisutural epithelium, ratio inflammatory cells (ICs)/epithelial cells and IC/fibroblasts, and presence/absence of bacterial plaque in the suture track.

Results: A perisutural epithelial sheath was forming within 3 days. The cross-sectional area of the epithelium increased with time for both suture materials ($p = 0.003$) but was particularly pronounced for the silk sutures in the absence of AT. Clusters of IC were present in the perisutural connective tissue and epithelium. Over time, a more prominent increase in IC/fibroblasts was evident for the silk sutures in the absence of AT. The pooled material revealed a significantly higher IC/fibroblast ratio for silk compared with ePTFE sutures ($p = 0.017$). Bacterial plaque influx was detected in 6/9 silk and 0/9 ePTFE suture channels in the presence, and 6/6 and 3/6 suture channels, respectively, in the absence of AT.

Conclusions: AT may reduce biofilm formation and inflammation along the suture track. Braided silk, however, elicits more severe tissue reactions than ePTFE regardless of infection control.

Key words: beagle dogs; histology; periodontics; silk/expanded polytetrafluoroethylene; suture materials

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Proper closure and stabilization of wound margins by sutures are critical events that may influence the success of any surgical procedure. However, the presence of foreign materials in a wound significantly enhances the susceptibility of host tissue's infection (Blomstedt et al. 1977, Österberg & Blomstedt 1979). Moreover, the number of bacteria needed to establish infection is reduced 10,000-fold by the presence of a silk suture (Howe & Marston 1962). Thus, the ultimate consequence of suturing can be postoperative infection resulting in compromised wound healing.

The mechanism by which suturing and choice selection of suture material may influence surgical outcome is not totally clear. Exudative foreign body reactions to sutures may give rise to inflammatory responses, decrease resistance to infection, and ultimately impair wound healing (Trimbos et al. 1989). Sutures may also serve as a pathway for bacteria into a surgical wound, a physical process likely enhanced by the capillary action of the suture material (Chu & Williams 1984). The physical configuration of some suture materials may protect contaminating bacteria and enable microorganisms to multiply beyond the access of the body's defence system (Everett 1970). Experimental and clinical data indicate that most wound infections begin around suture material left within the wound (Edlich et al. 1974, Varma et al. 1974) and that the infection rate in contaminated tissues containing sutures is significantly great-

er than that in contaminated needle-puncture tracts without sutures (Edlich et al. 1973). Furthermore, allergic reactions and reactions to the chemical structure of the suture material have been reported and may contribute to less than optimal wound healing (Getzen & Jansen 1966, Edlich et al. 1973, Varma et al. 1981).

Bacteria are present in all surgical wounds and, particularly, the oral cavity is characterized by a moist environment with a high infectious potential. The incidence of late suture complications such as local abscesses and sinus formation seems directly related to the degree of contamination at the time of suture placement. One study reported a 2.3% suture sinus rate in ''clean'' wounds closed with silk *versus* an 11% rate in contaminated wounds using the same suture material (Cutler & Dunphy 1941). Furthermore, the occurrence of abscess formation has been reported to be greater with braided, non-absorbable than with monofilament suture materials (Österberg & Blomstedt 1979) while sinus detection with synthetic, monofilament, non-absorbable sutures are uncommon (Everett 1970).

A previous study has shown that sutures placed in an infective environment may create a persistent acute inflammatory reaction superimposed on the healing process not unlike the tissue response seen in chronic periodontal diseases (Selvig et al. 1998). Furthermore, a study evaluating change in slack of the suture loop and change in ''tissue bite'', which are important factors in the assessment of immobilization of wound margins and healing by primary intention, concluded that silk sutures produce a significantly higher degree of slack and change in ''tissue bite'' than expanded polytetrafluoroethylene (ePTFE) sutures (Leknes et al. 2005). These results indicate that wound stability is not adequately maintained by silk sutures over a 7-day healing period.

Relatively inert synthetic suture materials are reportedly associated with less perisutural inflammation than sutures manufactured from natural materials (Selvig et al. 1998). The objective of this study was to evaluate tissue reactions to silk and ePTFE sutures in the presence and absence of anti-infective therapy (AT).

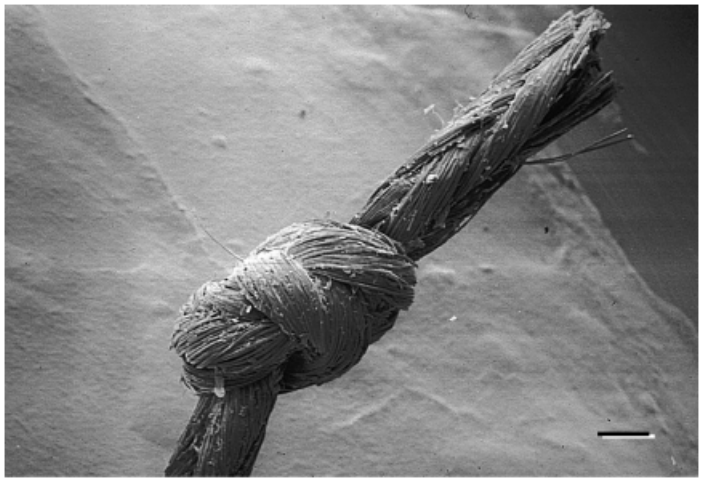

Fig. 1. Scanning electron microscopy of a silk suture illustrating a multifilament, braided structure (bar = 0.05 mm).

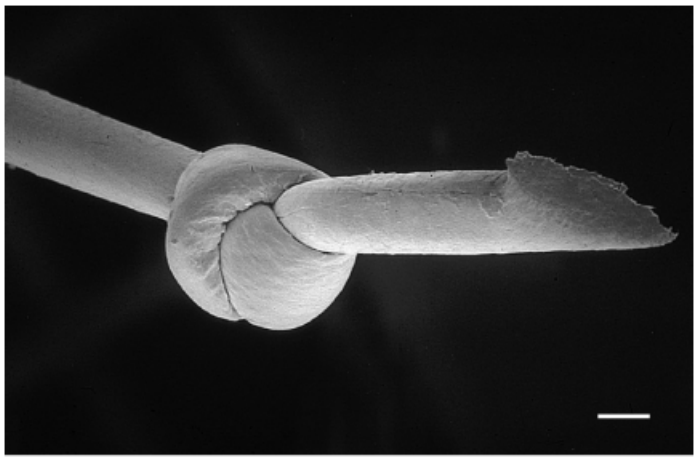

Fig. 2. Scanning electron microscopy of an expanded polytetrafluoroethylene suture illustrating a monofilament structure (bar = 0.05 mm).

Material and Methods

Animals

Six adult Beagle dogs were used. Three animals received daily AT including topical application of a 2% chlorhexidine digluconate solution and intra-muscular administration of a broad-spectrum antibiotic (Combiotic, Pfizer Inc., New York, NY, USA). The remaining animals did not receive AT. All animals were fed a soft-consistency laboratory diet supplemented with vitamins throughout the experimental period. The research protocol was approved by the Institutional Animal Research and Use Committee, Loma Linda University.

Experimental suture materials

The following suture materials were inserted:

- non-absorbable, multifilament silk suture (Ethicon GmbH & Co, KgD-22851, Norderstedt, Germany), USP size 4-0, equipped with a reverse cutting needle FS-2 (Fig. 1);
- non-absorbable, monofilament ePTFE suture (W.L. Gore & Assoc. Inc., Flaggstaff, AZ, USA), CV-5, equipped with a comparable reverse cutting needle RT-16 (Fig. 2).

Experimental surgery

Preparation of the experimental site

Surgical procedures were performed under intravenous sodium pentobarbital anaesthesia (Nembutal Sodium Solution, Abbott Laboratories, North Chicago, IL, USA). Following elevation of mucoperiosteal flaps, the mandibular premolar

teeth (P1, P2, P3, and P4) in contralateral jaw quadrants were reduced to the level of the alveolar crest. The pulps were sealed and the flaps were repositioned to cover the reduced teeth by using vertical mattress sutures. The sutures were removed 10 days postoperatively and the wounds were allowed to heal for another 2 weeks.

Placement of experimental sutures

Experimental single interrupted sutures were placed within the mandibular keratinized gingiva in contra-lateral jaw quadrants at 14, 7, and 3 days prior to biopsy. An attempt was made to keep the buccolingual direction, bite (5–6 mm), and depth of the sutures as standardized as possible. Each suture was tied with a surgical knot, with a minimum of tissue tension. The animals were euthanized using an overdose of pentobarbital (100 mg/kg), following sedation with acepromazine (0.1 mg/kg)/buprenorphine HCl (0.02 mg/kg) at which time the experimental sutures with surrounding tissue were removed for histologic processing and evaluation.

Specimen handling and histologic analysis

Harvested tissues were immersed in a formaldehyde/glutaraldehyde fixative for minimum 48 h, rinsed in water, dehydrated in ethyl alcohol, and embedded in epoxy resin following routine procedures. The specimens were oriented so that sections, 2 µm in thickness, could be produced parallel to the tissue surface, thus yielding a cross-section of the suture in situ in each section. Individual sections were mounted on glass slides and stained with 0.2% toluidine blue for light microscopic examination. A total of 36 sutures were harvested and processed for histologic and histometric examination by one examiner masked to the experimental protocol. However, both the silk and the ePTFE sutures were identifiable because of their microscopic characteristics. Two central sections displaying the most distinct histology were selected for analysis from each specimen and tabulated values represent means of the two sections.

The following parameters were evaluated in each section:

- area of perisutural epithelium if present;
- proportion of inflammatory cells (ICs) to perisutural epithelial cells;
- proportion of ICs to fibroblasts;
- bacterial infiltration along the suture track (presence/absence).

Statistical analysis

The IC, epithelial cell, and fibroblast densities were calculated by counting the number of grid points falling on leucocyte-like cells and epithelial cells/fibroblasts, respectively. The proportions of ICs to epithelial cells and fibroblasts were then used as parameters for statistical comparisons between the two suture materials.

The histometric parameters were tabulated and animal means and standard deviation were calculated for each response variable. Analysis of variance with repeated measures (BMDP Statistical Software, BMDP 2 V, Los Angeles, CA, USA) was used to reveal any overall statistically significant difference between silk and ePTFE sutures, between time points, and to test the interaction between sutures and time points. If significance was shown, a

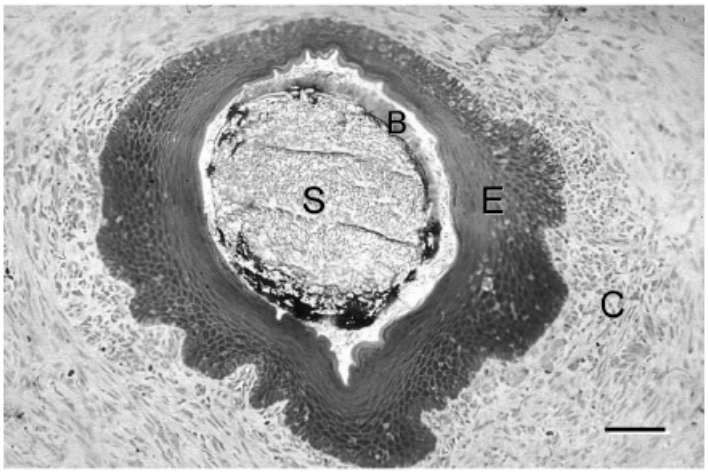

Fig. 3. Expanded polytetrafluoroethylene suture specimen at 14 days showing a layer of biofilm and more peripherally epithelium and connective tissue. No anti-infective therapy (S, suture; B, biofilm; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.2 mm).

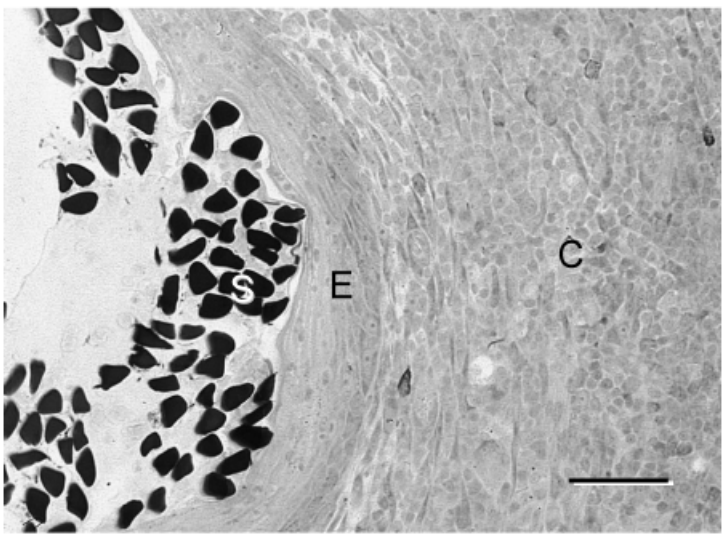

Fig. 4. Silk suture specimen at 3 days illustrating incipient epithelial ingrowth and scattered infiltration of inflammatory cells in the connective tissue. No anti-infective therapy (S, suture; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

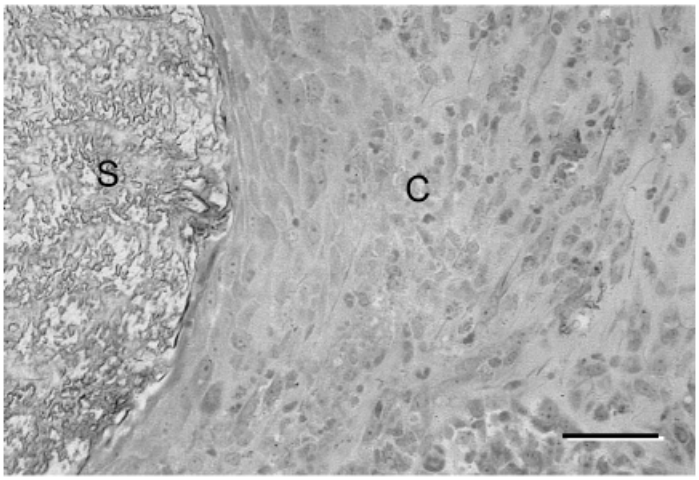

Fig. 5. Expanded polytetrafluoroethylene suture specimen at 3 days showing a direct contact between the suture material and the connective tissue. No anti-infective therapy (S, suture; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

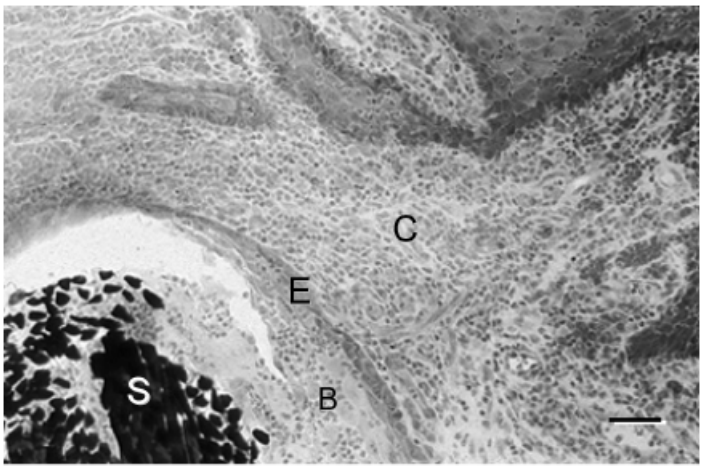

Fig. 6. Silk suture specimen at 3 days illustrating incipient perisutural epithelialization and areas with inflammatory infiltrate in the connective tissue. Anti-infective therapy (S, suture; E, epithelium; B, biofilm; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

paired *t*-test was used to test within- as well as between-suture differences at 3, 7, and 14 days. In all statistical analyses, the animal represented the experimental unit and a significance level (α) of 0.05 was used.

Results

Healing was generally uneventful. However, one 7-day and one 14-day silk suture were lost in separate animals. Both sutures were replaced by supplemental specimens. All suture sites in a third animal had to be excluded from analysis because of inadequate quality of the tissue preparation. Thus, 36 sutures were inserted while 30 suture site biopsies from five dogs were available for analysis.

Histologic findings

An overview of a suture site is shown in Fig. 3 portraying a suture surrounded by biofilm and more peripherally by perisutural epithelium and connective tissue with a variable accumulation of ICs. The 3-day specimens revealed some epithelial ingrowth along the suture track particularly for the silk suture sites (Fig. 4). The perisutural connective tissue was characterized by infiltration of scattered ICs and elements of immature granulation tissue (Figs 4–6). In some specimens, a biofilm-like structure was observed (Figs 4 and 6). Consistent differences in tissue reactions to sutures in the presence or absence of AT were not detected.

At 7 days, the braided silk sutures showed spreading of individual suture filaments and a pronounced bacterial invasion into the interstices (Fig. 7). For both suture materials, epithelialization of the suture channels occurred consistently in the presence and absence of AT (Figs 7–9). In some specimens, the most central part of the epithelium had a parakeratotic character with flattened cells retaining pyknotic nuclei (Figs 7 and 8). ICs were identified both as scattered individual cells and as discrete clusters in the epithelium and in the connective tissue regardless of AT (Figs 7–9).

By 14 days, the specimens were characterized by further keratinization of the central part of the epithelium (Figs 10 and 11). A distinct keratin layer was observed showing no individual cell borders or nuclei. Silk suture specimens in particular showed perisutural bacterial accumulation as well as accumulation between suture fibrils (Fig. 10). Individual microorganisms compatible in morphology with rods and fusiform bacteria were identifiable indicating the presence of a maturing biofilm. In several instances, zones of more mature granulation tissue with numerous capillaries had replaced the zone of IC infiltration (Fig. 11).

Histometric analysis

Summary statistics revealed that the mean area of the perisutural epithelial sleeve increased in the silk group with AT from 0.08 mm^2 at 3 days, to 0.22 mm^2 at 7 days, and to 0.27 mm^2 at 14 days (Table 1). The corresponding values for the silk group without AT were 0.05, 0.35, and 0.47 mm^2 at 3, 7, and 14 days, respectively. In the ePTFE group, the mean area of the perisutural epithelial sleeve increased from 0.01 mm^2 at 3 days, to 0.02 mm^2 at 7 days, and to 0.17 mm^2 at 14 days with AT (Table 1). The corresponding values for the ePTFE group in the absence of AT were 0.00 mm^2 at 3 days, 0.25 mm^2 at 7 days, and 0.26 mm^2 at 14 days.

The IC/epithelial cell ratio and IC/fibroblast ratio for the silk and ePTFE suture groups with and without AT are shown in Tables 2 and 3. Consistent within- or between-group differences in IC/epithelial cell ratio were not observed (Table 2). However, over time

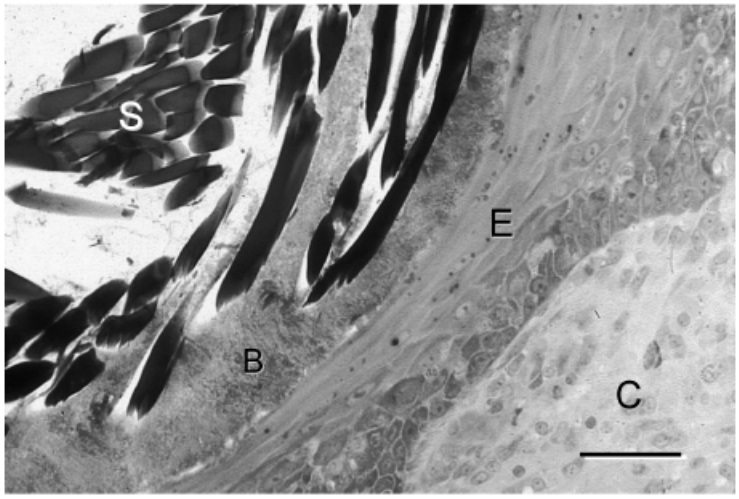

Fig. 7. Silk suture specimen at 7 days illustrating extensive spreading of individual filaments and pronounced invasion of bacteria into the interstices. The most central part of the epithelium has a parakeratotic appearance. Inflammatory cells are present in the epithelium as well in the connective tissue. No anti-infective therapy (S, suture; B, biofilm; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

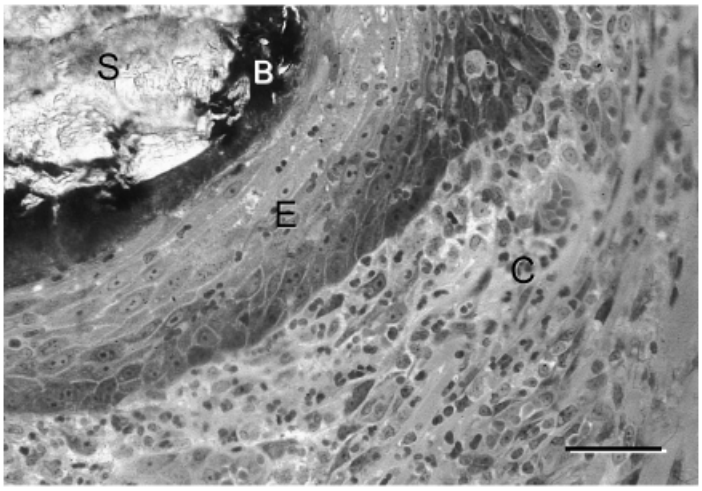

Fig. 8. Expanded polytetrafluoroethylene suture specimen at 7 days showing a significant layer of biofilm, parakeratotic epithelium, and connective tissue. Inflammatory cells are identified in the epithelium as well as in the connective tissue. No anti-infective therapy (S, suture; B, biofilm; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

an increase in the IC/fibroblast ratio was evident for both the silk and the ePTFE suture group regardless of AT. The increase was particularly prominent for the silk sutures in the absence of AT (Table 3).

Bacterial plaque influx was observed in 6/9 silk and 0/9 ePTFE suture channels in the presence, and 6/6 and 3/6 suture channels, respectively, in the absence of AT (Table 4).

For the pooled material, the area of the perisutural epithelium in the silk group ranged from 0.00–0.19 mm^2 at 3 days, from 0.12–0.47 mm^2 at 7 days, and from 0.13–0.58 mm^2 at 14 days (Table 5). The corresponding values for the ePTFE group were 0.00–0.02 mm^2 at 3 days, 0.00–0.36 mm^2 at 7 days, and 0.08–0.32 mm^2 at 14 days. Analysis of variance did not reveal significant differences between the silk and the ePTFE suture sites ($p = 0.06$). However, the p-value may indicate a stronger perisutural epithelial induction by silk sutures. Further statistical testing showed a significant increase in the area of perisutural epithelium for the silk suture group from 3 to 7 days ($p = 0.027$) and from 3 to 14 days ($p = 0.027$), and from 3 to 14 days for the ePTFE group ($p = 0.019$; Table 5).

For the epithelium, none of the between-group or the within-group ratio differences were significant (Table 6). Analysis of variance revealed a significantly higher IC/fibroblast ratio around silk than around ePTFE sutures ($p = 0.017$; Table 7). The Student t-test further showed that the between-group differences were significant by 7 ($p = 0.002$) and 14 days ($p = 0.005$), but not by 3 days ($p = 0.34$; Table 7).

Discussion

The development of infection in incisional wounds is one serious complication that may occur in surgically treated patients. Surgical infections may not only retard normal healing but may also induce life-threatening clinical situations, particularly in patients suffering from critical chronic illness. As suture material properties have the potential to influence wound healing negatively, a thorough understanding of the physical, mechanical, and biological properties of commonly used suture materials appears essential to optimize surgical management and reduce the infection risk. The purpose of this study was to evaluate tissue reactions at a natural and a synthetic suture material in the presence and absence of AT. A split-mouth protocol was used to reduce the influence of intra-individual variation, and inter-examiner variability was eliminated by having one operator performing all suture placements, measurements, and analyses.

To potentially evaluate early as well as late suture tissue reactions, a relatively wide observation interval was selected. The initial tissue response at 3 days was assumed to mainly reflect the surgical trauma of suture placement and to be comparable for all suture materials regardless of AT (Selvig et al. 1998). On the other hand, chemical structure and variability in biological inertness of the suture material rather than physical properties have been considered to be the most important factor in the early development of infection in contaminated surgical wounds (Edlich et al. 1973, Katz et al. 1981). All 3-day specimens were characterized by elements of immature granulation tissue and infiltration of scattered ICs in the connective tissue,

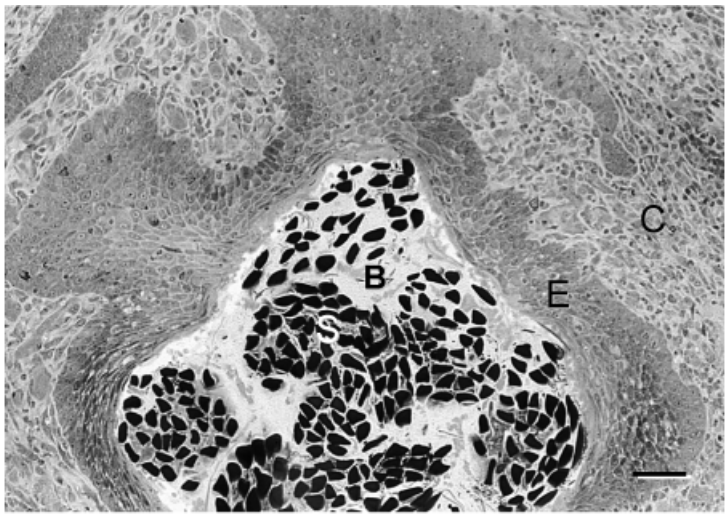

Fig. 9. Silk suture specimen at 7 days illustrating the braided appearance of the suture material surrounded by a non-circular epithelium. Scattered, inflammatory cells are seen in the epithelium and in the connective tissue. Anti-infective therapy (S, suture; B, biofilm; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

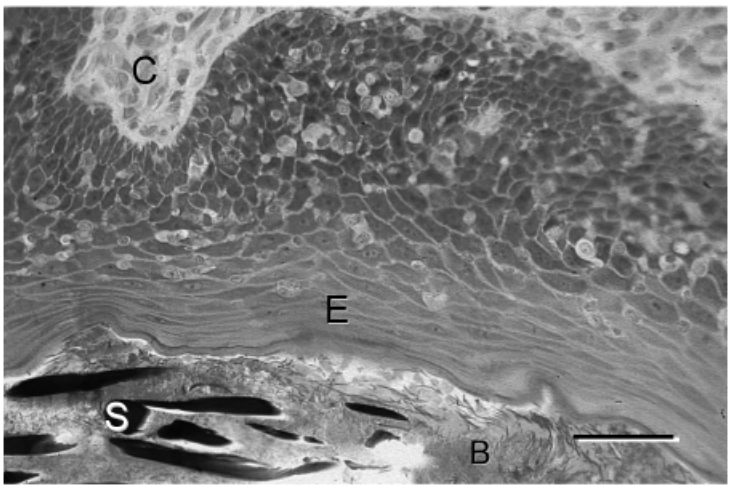

Fig. 10. Silk suture specimen at 14 days showing biofilm between the suture fibrils and more peripherally keratinized epithelium. No anti-infective therapy (S, suture; B, biofilm; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

Table 1. Area of perisutural epithelium (in mm^2) for silk and expanded polytetrafluoroethylene (ePTFE) sutures at 3, 7, and 14 days with and without anti-infective therapy

Time/Group	Anti-infective therapy ($N = 3$)			No anti-infective therapy ($N = 2$)		
	mean	min	max	mean	min	max
3 days						
Silk	0.08	0.00	0.19	0.05	0.00	0.10
ePTFE	0.01	0.00	0.02	0.00	0.00	0.00
7 days						
Silk	0.22	0.12	0.32	0.35	0.22	0.47
ePTFE	0.02	0.00	0.03	0.25	0.14	0.36
14 days						
Silk	0.27	0.13	0.35	0.47	0.35	0.58
ePTFE	0.17	0.08	0.32	0.26	0.22	0.29

indicating a quiet, non-traumatic reaction to both suture materials despite the difference in AT. The statistical testing of the pooled material confirmed the histologic findings by not revealing any between-group differences.

The histologic and histometric observations demonstrated that the cross-sectional area of the epithelium increased over time for both suture materials, but was particularly pronounced for the silk suture in the absence of AT. Bacterial accumulation was observed in 6/9 silk and 0/9 ePTFE suture channels in the presence, and in 6/6 and 3/6 suture channels, respectively, in the absence of AT. Healing of incisional wounds clearly benefits from adaptation and stabilization of the wound edges mediated by sutures during the first several days of healing (Sandberg & Zederfeldt 1963). At 7 days, wound healing under favourable circumstances is well advanced and at 10–12 days normal tissue tensile strength is almost re-created (Sandberg & Zederfeldt 1963). Particularly in oral tissues where contamination easily can progress to infection, early removal appears advisable (Selvig et al. 1998, Leknes et al. 2005). The present study demonstrated that by 3 days epithelial ingrowth had to some extent occurred along the suture track particularly for the silk sutures and that a biofilm-like structure was present. At 7 days, the braided silk sutures showed pronounced bacterial invasion also into the interstices of the suture material, and in some specimens parakeratotic epithelialization of the suture channel was evident both in the presence and absence of AT. Generally, the epithelium does not proliferate deep into connective tissue and microorganisms are eliminated during the early or late inflammatory phase of wound healing (Clark 1996). However, previous studies have reported an increase in suture slack over time, and have indicated that a lack of tight fit between suture and surrounding tissues allows epithelial invagination and conduction of bacteria into the connective tissue (Stillman et al. 1980, Selvig et al. 1998, Leknes et al. 2005). Collectively, these findings may explain the characteristic histologic findings presently reported.

Local abscess formation occasionally occurs around sutures and may result in a draining sinus that resolves only after suture removal or spontaneous suture exfoliation (Smeak & Wendelburg 1989).

The 14-day specimens were characterized by keratinization of the perisutural epithelium. Aggregations of rods and fusiform bacteria perisuturally as well as between the silk fibrils strongly indicate maturation of a potentially pathogenic biofilm. These observations support the notion advocating suture removal at the earliest biologically acceptable time (Gutmann & Harrison 1991). A pathogenic biofilm and orthokeratinization of the epithelium may contribute to the genesis of wound infection and increase the likelihood of foreign body reaction to the keratin layer of the perisutural epithelium (Alexander et al. 1967, Smeak & Wendelburg 1989).

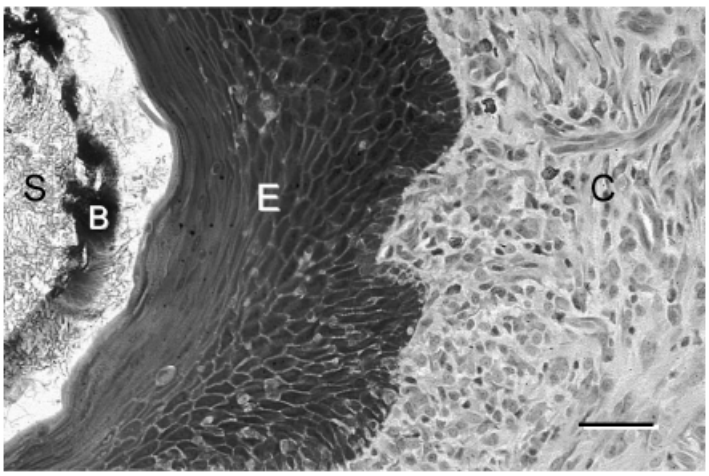

Fig. 11. Expanded polytetrafluoroethylene suture specimen at 14 days showing a layer of biofilm and heavily keratinized epithelium. In the connective tissue a more mature granulation tissue with copious number of fibroblasts and capillaries dominated. No anti-infective therapy (S, suture; B, biofilm; E, epithelium; C, connective tissue; toluidine-blue stain; bar = 0.1 mm).

Table 2. Inflammatory cell to epithelial cell ratio for silk and expanded polytetrafluoroethylene (ePTFE) sutures at 3, 7, and 14 days with and without anti-infective therapy

Time/Group	Anti-infective therapy ($N = 3$)			No anti-infective therapy ($N = 2$)		
	mean	min	max	mean	min	max
3 days						
Silk	0.04	0.00	0.07	0.02	0.00	0.03
ePTFE	0.12	0.00	0.24	0.00	0.00	0.00
7 days						
Silk	0.06	0.02	0.09	0.09	0.09	0.09
ePTFE	0.00	0.00	0.00	0.12	0.03	0.21
14 days						
Silk	0.07	0.00	0.16	0.05	0.05	0.06
ePTFE	0.05	0.00	0.10	0.04	0.03	0.05

Table 3. Inflammatory cell to fibroblast ratio for silk and expanded polytetrafluoroethylene (ePTFE) sutures at 3, 7, and 14 days with and without anti-infective therapy

Time/Group	Anti-infective therapy ($N = 3$)			No anti-infective therapy ($N = 2$)		
	mean	min	max	mean	min	max
3 days						
Silk	0.55	0.09	0.90	0.22	0.13	0.31
ePTFE	0.12	0.09	0.13	0.35	0.30	0.40
7 days						
Silk	0.31	0.24	0.35	0.37	0.35	0.38
ePTFE	0.15	0.07	0.23	0.16	0.08	0.23
14 days						
Silk	0.52	0.47	0.59	0.48	0.23	0.73
ePTFE	0.20	0.08	0.31	0.15	0.04	0.26

At all observation periods, ICs were present in perisutural epithelium and connective tissue, and over time a prominent increase in the IC/fibroblast ratio was evident at the silk suture sites in the absence of AT. For the pooled material, no between- or within-group ratio differences were significant for the epithelium, while a significantly higher IC/fibroblast ratio was observed for the silk compared with the ePTFE suture sites at 7 and 14 days. It is well accepted that the physical configuration of the suture material is an important factor with regard to infection rate and potential (Österberg & Blomstedt 1979, Chu & Williams 1984, Abi Rached et al. 1991, Selvig et al. 1998, Leknes et al. 2005). Multifilament sutures may conduct surface bacteria from a contaminated to a sterile area by capillary action and thereby contribute to induction or spread of infection (Stillman et al. 1980). Furthermore, for non-absorbable sutures physical configuration is probably of greater significance for their ability to attract bacteria than the chemical nature or surface finish (Chu & Williams 1984, Smeak & Wendelburg 1989). The significantly higher IC/fibroblast ratio at 7 and 14 days, but not at 3 days, for the silk compared with ePTFE suture sites reflects an increased IC mobilization around silk sutures probably because of the braided, capillary structure that facilitates invasion of bacteria and other noxious contaminants from the oral cavity. The signs of the immunologic mobilization persisting throughout the 14-day observation period illustrate the critical role of the infection factor. On the other hand, IC counts within the epithelium did not reveal any significant between-group differences. The findings are in harmony with previous studies indicating

Table 4. Number of suture tracks with bacterial accumulation for silk and expanded polytetrafluoroethylene (ePTFE)

Time/Group	Anti-infective therapy	No anti-infective therapy
3 days		
Silk	0/3	2/2
ePTFE	0/3	0/2
7 days		
Silk	3/3	2/2
ePTFE	0/3	2/2
14 days		
Silk	3/3	2/2
ePTFE	0/3	1/2
	Silk 6/9	Silk 6/6
	ePTFE 0/9	ePTFE 3/6

Table 5. Area of perisutural epithelium (in mm^2) around silk and expanded polytetrafluoroethylene (ePTFE) sutures at 3, 7, and 14 days ($N = 5$)

Time/Group	Mean	SD	Min	Max
3 days				
Silk	0.07	0.08	0.00	0.19
ePTFE	0.01	0.01	0.00	0.02
7 days				
Silk	0.27	0.13	0.12	0.47
ePTFE	0.11	0.15	0.00	0.36
14 days				
Silk	0.35	0.16	0.13	0.58
ePTFE	0.20	0.11	0.08	0.32

Between-group differences: NS, not significant ($p = 0.06$).
Within-group changes over time: $^{*}p < 0.05$.

Table 6. Inflammatory cell to epithelial cell ratio for silk and expanded polytetrafluoroethylene (ePTFE) sutures at 3, 7, and 14 days ($N = 5$)

Time / Group	Mean	SD	Min	Max
3 days				
Silk	0.03	0.03	0.00	0.07
ePTFE	0.07	0.11	0.00	0.24
7 days				
Silk	0.07	0.03	0.02	0.09
ePTFE	0.05	0.09	0.00	0.21
14 days				
Silk	0.06	0.06	0.00	0.16
ePTFE	0.05	0.04	0.00	0.10

Between-group differences: NS, not significant.
Within-group changes over time: NS, not significant.

Table 7. Inflammatory cell to fibroblast ratio for silk and expanded polytetrafluoroethylene (ePTFE) sutures at 3, 7, and 14 days ($N = 5$)

Time / Group	Mean	SD	Min	Max
3 days				
Silk	0.42	0.35	0.09	0.90
ePTFE	0.21	0.13	0.09	0.40
7 days				
Silk	0.34	0.05	0.24	0.39
ePTFE	0.15	0.08	0.07	0.23
14 days				
Silk	0.51	0.18	0.23	0.73
ePTFE	0.18	0.12	0.04	0.31

Between-group differences: $^{**}p < 0.01$; NS, not significant.
Within-group changes over time: NS, not significant.

that the cellular mobilization is expressed to a lesser degree within the epithelium and that subtle differences might be undisclosable with the present histometric evaluation (Leknes et al. 1996, 2005).

In this study, one group of animals received daily AT including topical application of 2% chlorhexidine solution and daily intra-muscular administration of a broad-spectrum antibiotic. This regimen definitely was responsible for the reduced number of suture tracks exhibiting bacterial accumulation particularly for the ePTFE suture group. However, only minor consistent histologic and histometric between-group differences were disclosed. Studies evaluating regenerative surgery in intra-bony and in Class II furcation defects using ePTFE barrier membranes have reported bacterial invasion of the wound area and colonization of the exposed membrane regardless of AT (Selvig et al. 1992, Demolon et al. 1993, 1994, MacDonald et al. 1998). These clinical trials further concluded that the extent of oral exposure and bacterial contamination of the membrane were indicators of the long-term success of the regenerative procedure repeatedly illustrating the critical role of the infection factor besides the limited effect of AT in an oral environment (Selvig et al. 1992, MacDonald et al. 1998).

Within the limitation of this study, it can be concluded that:

- placement of sutures in keratinized gingiva elicits an inflammatory reaction perisuturally regardless of AT;
- AT reduces bacterial invasion as well as connective tissue inflammatory reaction;
- the inflammatory reaction is more pronounced at silk than at ePTFE sutures;
- multifilament, braided silk suture appears to enhance bacterial invasion along the suture track compared with monofilament ePTFE suture;
- for both suture materials, the amount of perisutural epithelium increases over time.

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