Microbial Adherence on Various Intraoral Suture Materials in Patients Undergoing Dental Surgery

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Purpose: Sutures used in oral surgery should avoid or limit bacterial adhesion and proliferation to those parts exposed to oral fluids. Hence, microbial colonization on various intraoral suture materials from patients undergoing dental surgery was compared.

Patients and Methods: During dentoalveolar surgery, various suture materials were used in 60 patients, who were randomly divided into 5 groups of 12. In each group, silk was placed intraorally in association with a different type of suture (ie, Supramid, Synthofil, Ethibond Excel, Ti-cron, Monocryl) at the same site to compare microbial colonization intraindividually. Eight days postoperatively, the sutures were removed, and adhered micro-organisms were isolated, counted, and identified through enzymatic activities and fermentation of sugars.

Results: In all 60 patients, silk sutures exhibited the smallest affinity toward the adhesion of bacteria compared with considerable proliferation with nonresorbable multifilament sutures (Supramid, Synthofil, Ethibond Excel, Ti-cron). On the contrary, the microbial load was significantly lower when absorbable monofilament Monocryl was used. A greater quantity of bacteria was found on nonresorbable sutures than on absorbable ones, and nearly 2 times more facultative anaerobic bacteria were isolated in total.

Conclusions: Our results show that bacteria adhere with different affinity to various types of suture materials. Absorbable silk and Monocryl exhibited the smallest number of adherent bacteria. Colonization by pathogens on sutures leads to the recommendation that sutures should be removed as early as possible after surgery is performed, to eliminate or to limit the reservoir for oral pathogens. This recommendation is dependent on whether the suture is absorbable.

Sutures play an important role in wound healing after surgical intervention, allowing the reapproximation of tissues separated by surgical or accidental trauma, the promotion of primary healing, and the control of hemorrhage; therefore, suture material must be selected carefully. In particular, sutures used in oral and maxillofacial surgery behave differently from those used in other parts of the body because of the quality of body tissues involved, the constant presence of saliva, the high levels of vascularization, and functions related to speech, mastication, and swallowing. Good sutures require specific physical characteristics and
properties, such as good resistance to traction, dimensional stability, lack of memory, good knot security, and sufficient flexibility to avoid damage to the oral mucosa. At the same time, they must avoid or limit bacterial adhesion and proliferation to those parts exposed to oral fluids, thereby avoiding contamination inside the wound. A good suture material must show a brief exudative phase and must not interfere with cellular proliferation or connective tissue organization. The search for more appropriate suture materials has resulted in a variety of commercially available natural and synthetic, absorbable and non-absorbable sutures. The literature on suture materials of various types is extensive. Among natural suture materials, many surgeons consider silk suture as the standard of performance (superior handling characteristics). This suture, made up of 70% protein fiber and 30% extraneous material, such as gum, may be coated with beeswax or silicone. Although classified as a nonresorbable material, silk suture becomes absorbed by proteolysis and often is undetectable in the wound within 2 years. Tensile strength decreases with moisture and is lost within 1 year. The problem with silk suture is the acute inflammatory reaction triggered by this material (protein and extraneous material); host reactions lead to encapsulation by fibrous connective tissue. In fact, sutures placed in the gingival and oral mucosa may produce a prolonged tissue response that is most likely a result of the continual influx of microbial contamination along the suture channel. Microbial invasion of the suture track is a common sequela, regardless of the material used, especially for silk; synthetic monofilament suture elicits a mild inflammatory response. Moreover, after dentoalveolar surgery, biofilms may develop in sutures: Consequences include inflammation of the surrounding tissues and formation of a reservoir for pathogens. In such biofilms, bacteria are hidden from host immune responses and are much less susceptible to antibiotics.

Therefore, given that besides silk, many different synthetic suture materials are commonly used in oral surgery, the aim of this study was to examine oral microbial colonization on various intraoral suture materials from patients undergoing dentoalveolar surgery. We focused on the type and number of strains that can be isolated and noted differences between the types of sutures that are used.

Patients and Methods

SUTURE MATERIALS

Five different types of synthetic suture materials usually are used in dentoalveolar surgery; these were examined and compared with silk (natural, black braided):

1. Supramid (B. Braun, Melsungen, Germany): Black, nonabsorbable, pseudomonofilament suture made of polyamide.
2. Synthofil (B. Braun, Aesculap, Bethlehem, PA): Green, nonabsorbable, multifilament suture composed of braided polyethylene terephthalate fibers and coated uniformly with polyethylene vinyl acetate.
3. Ethibond Excel (Johnson & Johnson Intl, Hamburg, Germany): Green, nonabsorbable, braided suture composed of polyethylene terephthalate and coated with polybutylate.
5. Ticron (Sherwood, Davis & Geck, Danbury, CT): Blue, nonabsorbable, braided multifilament suture composed of polyethylene terephthalate and coated with silicone.

PATIENTS AND STUDY DESIGN

Suture materials were applied to 60 patients during dentoalveolar surgery, such as bilateral lower third molar extraction, at the Department of Clinical Physiopathology, SCDU Maxillofacial Surgery, University of Turin (Turin, Italy). Patients were randomly divided into 5 groups of 12. In each group, silk was placed intraorally to suture the right third molar, and 1 of 5 different types of synthetic suture was placed on the other side (left third molar) so that microbial colonization could be compared intrindividually. Eight days postoperatively, suture materials were removed according to standard procedures and under sterile conditions. All patients were treated within the normal standard of care, which included the suture materials used.

ISOLATION AND DIFFERENTIATION

Removed sutures were immediately transferred into sterile tubes that contained thioglycollate medium (Oxoid SpA, Garbagnate Milanese, Milan, Italy) and were processed within 1 hour. Serial 10-fold dilutions were prepared for each sample in saline (0.9% NaCl) so that the number of colony-forming units (cfu/mL) could be determined; 100 μL of each dilution was plated on Tripticase Soy agar (Oxoid) and on various media that were suitable for aerobic and anaerobic bacteria. In particular, the following media were used: Columbia agar base plus debrinated horse blood (5%), Nutrient agar (Oxoid), and Todd Hewitt Broth plus Technical agar (1.5%) (Biolife, Milan, Italy). To quantify the total microbial number or the number of specific Gram-negative anaerobic obligates, samples were plated on Schaedler agar plus 5% blood (Oxoid) and Schaedler Kana-Vanco agar supplemented with 5% blood (Oxoid), respectively. Sab-
Dextrose agar (Biolife) was used to isolate yeasts. Plates were incubated for 2 to 4 days at 37°C under aerobic conditions for aerobic bacteria and yeasts, under 5% to 10% carbon dioxide (CO₂) atmosphere for aerobic/anaerobic facultative bacteria, and for 5 to 9 days at 37°C under strictly anaerobic conditions within an anaerobic system (Anaerocult IS; Merck Bracco, Milan, Italy) for anaerobe obligate and facultative bacteria. After incubation, the number of colony-forming units per milliliter was recorded. All colonies with different morphologies, colors, sizes, and hemolytic reactions were selected so that as many of the predominant bacterial types as possible could be obtained. Isolated colonies were streaked on Columbia blood agar plates to get a pure culture. For morphologic analysis, Gram staining was performed and cellular morphologies were determined by light microscopy. Studies of enzymatic activities and fermentation of sugars were used to identify isolated facultative anaerobic/aerobic microorganisms. These biochemical tests were performed with commercially available Api systems (BioMérieux, Rome, Italy) such as API 20E, API 20NE, API NH, and API Staph for aerobic bacteria, and API Strep for anaerobic facultative bacteria. API 20 A and rapid ID32A were used to identify anaerobic obligate bacteria, and ID 32C was used for the identification of yeasts. Tests were performed according to the manufacturers’ instructions.

**Results**

Patients showed no signs of local infection at the time of suture removal. Within a 3-week recall, no complications of wound healing were observed. Figure 1 shows the numbers of aerobic and anaerobic strains isolated from the 5 sutures compared with silk. The quantity of in vivo adhered bacteria was found to be dependent on the type of suture material used. In all 60 patients, silk sutures exhibited the smallest affinity toward the adherence of bacteria; in contrast, considerable proliferation was seen with the other suture materials. In fact, the highest incidence of bacterial growth frequently occurred with nonabsorbable multifilament sutures such as Supramid (7 of 12 patients), Synthofil (9 of 12), Ethibond Excel (8 of 12), and Ti-cron (9 of 12). On the contrary, the bacterial load was significantly smaller in all 12 patients, compared with that of nonabsorbable sutures, when monofilament absorbable Monocryl was used (Fig 1). Aerobic and anaerobic bacteria were isolated in nearly equal quantities (cfu/mL) on each suture. The aerobic bacterial strains *Streptococcus spp.* (S. mitis, S. sanguis, S. oralis, S. mutans, *Gemella morbillorum*), *Staphylococcus warneri*, *Neisseria spp.*.*Actinomyces spp.*, and *Pasteurella spp.*, and the anaerobic bacterial strains *Veillonella parvula*, *Peptostreptococcus spp.*, *Actinobacillus spp.*, *Prevotella spp.*, and *Fusobacteria spp.* were found predominantly on all types of sutures. A greater quantity of bacteria was found on
nonresorbable sutures than on absorbable ones, and nearly 2 times more facultative anaerobic bacteria were isolated in total. In 2 cases, only the aerobic pathogen Pseudomonas aeruginosa and the yeast Candida albicans were found on Supramid and Synthofil, respectively.

Discussion

The choice of the best overall suture is related to the specific procedure to be undertaken. Usually, the surgeon selects the smallest suture that adequately holds the healing wound edge: In anatomic regions such as the nasal and oral mucosa that demand higher tensile strength, multifilament synthetic suture material (MUS) is preferred, and in areas with lower tensile strength, monofilament suture material (MOS) is suggested. Tissue healing speed and level of patient cooperation may affect the search for a suitable suture: Nonresorbable sutures are used when a slow recovery is expected, whereas absorbable sutures are preferred with noncollaborative patients. Furthermore, sutures’ threads should limit bacterial adhesion and proliferation to those parts exposed to oral fluids, thereby avoiding contamination inside the wound. Sutures placed after surgery are partially embedded in tissue and partially bathed in saliva, with a mean concentration of approximately 7.5 × 10⁸ microorganisms/mL. Sutures placed in gingival and oral mucosa may hence produce prolonged tissue responses as a consequence of continual influx of microbial contamination along the suture channel. Durdey and Bucknall found that MUS produces more prolonged tissue responses and harbors a larger quantity of bacteria compared with MOS. Many clinicians, however, prefer MUS because MOS is more difficult to manipulate, exhibits poor knot security, and has sharp ends that irritate oral tissues. The roughened exterior of braided suture causes physical damage when placed; this produces the differential reaction. Use of MOS has been challenged by some studies, which suggest that it can “wick” bacteria into oral tissues, causing severe inflammation. Additionally, after dentoalveolar surgery, biofilms may develop in sutures, resulting in inflammation of the surrounding tissues or the formation of a reservoir for pathogens; in such biofilms, bacteria are hidden from host immune responses and are much less susceptible to antibiotics. The inflammation caused by these bacteria produces erythema that surrounds the puncture wounds and leads clinicians to suspect that the suture could wick the bacteria into the surgical site itself; the swelling could open spaces between the fibrils, thereby enhancing the capillary action of the suture and the interstitial space in which bacteria may lodge.

Although investigators have conducted a variety of in vitro and in vivo studies in attempts to identify characteristics of suture material that produce differential tissue reaction to monofilament and multifilament suture materials, until this study was undertaken, the interactions between bacteria and responsible biomaterials were rarely considered. The association of silk suture with, respectively, Supramid, Synthofil, Ethibond Excel, Monocryl, and Ti-cron suture, was investigated in the same patient and at the same location. Eight days postoperatively, sutures were removed, and adherent microorganisms were isolated and identified. Patients showed no signs of local infection at the time of suture removal. From our in vivo results, it was established that differences can be seen related to the colonization of sutures, and that silk microbiologically should be the preferred suture for dentoalveolar surgery over the other synthetic materials analyzed. In fact, for all 60 patients, silk sutures exhibited the smallest affinity toward adherence of bacteria; in comparison, considerable proliferation was shown with the other suture materials (Fig 1). In particular, the highest incidence of microbial growth frequently occurred with nonabsorbable multifilament sutures such as Supramid (7 of 12 patients), Synthofil (9 of 12), Ethibond Excel (8 of 12), and Ti-cron (9 of 12). On the contrary, the microbial load was significantly lower than that of nonabsorbable sutures, in all 12 patients, when absorbable monofilament Monocryl was used (Fig 1), confirming the findings of Otten et al. These authors showed that absorbable Monocryl allowed less bacterial colonization than was permitted by nonabsorbable Deknalon (Deknatel; Genzyme GmbH, Lubeck, Germany) in humans. Through animal models, Merritt et al showed that the risk of infection varies with chemistry and configuration of the material, indicating that infection rates with multifilament sutures were higher than with monofilament ones.

From our in vivo results, silk is seen to be less prone to support bacterial colonization than are other suture materials, in contrast with the literature data. It must be emphasized that most studies on this matter have been conducted under experimental conditions that were different from our in vivo situation, such as in vitro bacterial adherence assays for pathogens such as Staphylococcus aureus and Escherichia coli or experimental models of wound infection in animals. The smallest affinity of silk toward bacterial adhesion shown in our study might be explained by its lower wicking effect, as documented by some authors. To elucidate the mechanism of wicking and to devise strategies to prevent bacterial transmission by sutures, investigators considered passive bacterial transmission through fluid movement of bacteria attained by colony growth and expansion. Their
in vitro results suggested that silk produces less fluid movement by capillary action than is produced by other braided sutures, and it seems to transmit bacteria mechanically less often than do other suture materials. These data are in agreement with those of other authors who found no differences in serious infections when silk was used and was compared with other MUS materials. In our study, a greater number of bacteria were found on nonresorbable sutures (Supramid, Synthofil, Ethibond Excel, and Ti-cron) than on absorbable ones (silk and Monocryl), and nearly 2 times more facultative anaerobic bacteria were isolated in total. Aerobic and anaerobic bacteria were isolated in nearly equal quantities (cfu/mL) on each suture. The aerobic bacterial strains Streptococcus spp. (S. mitis, S. sanguis, S. oralis, S. mutans, Gemella morbillorum), Staphylococcus warneri, Neisseria spp., Actinomyces spp., and Peptostreptococcus spp., and the anaerobic bacterial strains Veillonella parvula, Peptostreptococcus spp., Actinobacillus spp., Prevotella spp., and Fusobacterium spp. were found to be predominant on all sutures. Because of their ability to adhere to sutures, these bacteria consequently may act as a focus of odontogenic infection; in fact, fusobacteria, peptostreptococci, prevotella, and streptococci species are usually identified in odontogenic infections, resulting in a potential risk factor for wound healing. S. mitis, S. sanguis, and S. oralis, which are well known as colonizers of tooth surface and part of the normal flora, are described as endocarditis pathogens. Recent studies have reported that systemic disease initiated by the anaerobic species Fusobacterium spp., Prevotella spp., and Peptostreptococcus spp., such as aspiration pneumonia, organ abscess, and septicemia associated with cancer chemotherapy or radiotherapy, may have oral causes. Older patients with poor oral health and cardiac patients, as well as immunocompromised patients, constitute risk groups for bacterial endocarditis and other systemic diseases of oral origin. Recently, Otten et al showed that bacteremia may result from the removal of sutures, and suture removal-induced bacteremia was described to present a possible risk for endocarditis, involving intraoral bacteria such as S. sanguis, S. oralis, and S. salivarius. Hence, the suggestion was made to remove sutures as early as possible (6 to 10 days) after oral surgery.

In conclusion, our results show that bacteria may adhere with varying levels of affinity to various types of suture materials. Absorbable silk and Monocryl should be the preferred sutures for dental surgery because they are the ones to which the smallest quantity of bacteria adhered. Colonization with pathogens on sutures leads to the recommendation that sutures should be removed as early as possible after surgery to eliminate the reservoir for oral pathogens. This recommendation is dependent on whether the suture is absorbable.

References
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