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Original Article / Оригинални рад

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Microbial Adherence Affinity and Clinical Characteristics of Polypropylene versus Silk Sutures in Oral Surgery

Свилени и полипропиленски материјал за шавове у оралној хирургији – колонизација микроорганизмима и клиничке карактеристике

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Microbial Adherence Affinity and Clinical Characteristics of Polypropylene versus Silk Sutures in Oral Surgery

Свилени и полипропиленски материјал за шавове у оралној хирургији – колонизација микроорганизмима и клиничке карактеристике

SUMMARY

Introduction/Objective The purpose of this study was to compare polypropylene (PPS) and silk suture (SS) materials in terms of bacterial adherence and clinical features including the impact on soft tissue healing.

Methods A total of 10 healthy patients were included in this study. Unilateral upper and lower wisdom teeth were extracted at the same time and wounds were sutured with different threads (one monofilament–PPS and one multifilament–SS)**.** Stitches were removed 7 days postoperatively. Real-time PCR was used to analyze bacterial adherence. Intraoperative handling and easiness of removal were assessed with the help of Visual Analogue Scale. Landry healing index was used for evaluation of soft tissue healing.

Results Significantly more pronounced bacterial adherence was found on SS compared to PPS (p=0.005). *S*uperior intraoperative handling properties were registered suturing with PPS compared to SS (p=0.005). Soft tissue healing was significantly better around PPS, both on the 3rd and 7th postoperative day (p=0.016). Patient discomfort was slightly higher for PPS, but without statistical significance.

Conclusion Polypropylene suture material showed significantly lower bacterial adherence and superior clinical features compared to silk, including better soft tissue healing.

Keywords: bacterial adherence; oral soft tissue healing; non-absorbable suture materials; oral surgery; real time-PCR

САЖЕТАК

Увод/Циљ Циљ ове студије био је поређење свиленог (СК) и полипропиленског конца (ППК) у погледу пријемчивости за бактерије и клиничких карактеристика укључујући утицај на зарастање меког ткива у усној дупљи.

Методе У студију је укључено 10 здравих испитаника код којих су хируршки извађеи горњи и доњи умњак са једне стране истовремено, а ране су ушивене различитим концима (један монофиламентни–ППК и један полифиламентни–СК). Квантификација бактерија на узорцима конаца који су уклоњени седам дана после операције урађена је методом ланчане реакције полимеразе у реалном времену. Орални хирург је уз помоћ Визуелне аналогне скале оцењивао лакоћу интраоперативног руковања као и лакоћу уклањања конаца. За процену квалитета зарастања меког ткива коришћен је индекс по Ландрију.

Резултати Статистички значајно више бактерија нађено је на свим узорцима СК у поређењу са ППК (p=0,005). ППК се показао значајно лакшим за интраоперативно руковање у односу на СК (p=0,005). Такође, зарастање меког ткива, 3. и 7. дана постоперативно, било је значајно успешније око ППК него око СК (p=0,016). Непријатност због присуства конаца била је већа код примене ППК у односу на СК, али без статистички значајне разлике.

Закључак Полипропиленски конац је у односу на свилени конац показао значајно мању пријемчивост за бактерије и боље клиничке карактеристике укључујући и боље зарастање меког ткива.

Кључне речи: бактеријска пријемчивост; зарастање меког ткива; нересорптивни хируршки конци; орална хирургија; *real time-PCR*

INTRODUCTION

It is widely accepted that *per primam* soft tissue healing, as well as the absence of infection during the postoperative period, is crucial for a successful outcome of every procedure in oral surgery. Primary healing is most frequently obtained by means of sutures, which serve as tissue support until enough tensile strength and integrity is regained [1, 2]. Although various suture materials are used for wound closure, one should always opt for the best thread in regard to biocompatibility and handling characteristics. According to their origin, suture materials can be natural or synthetic. Depending on the number of threads, monofilament sutures (made of a single strand or filament) and multifilament sutures (made of several braided/twisted strands or filaments) may be distinguished.

Nowadays, in oral surgery, silk is the only natural suture material that is still widely used. Easiness of manipulation and low cost are the main reasons for that [3, 4]. However, many studies

emphasized that tissue reaction is more pronounced around sutures of natural origin than around synthetic ones [5–10]. Technological advancement in the field of synthetic fibers has enabled the development of high quality threads, very stable in terms of physical configuration, showing high biocompatibility [11, 12, 13].

From a biological point of view, the ideal suture material should be as inert as possible and should not impede tissue regeneration. Due to anatomical and physiological complexity of the oral cavity, clinical and histological studies have suggested quite different oral tissue reactions to sutures in comparison with other parts of human body [6, 14]. Oral cavity may be compared to a bioreactor, where in warm and damp environment bacteria are in constant interaction with present food detritus, enhancing the risk of superinfection [1]. It has been shown that in the presence of sutures, only 100 CFU of bacteria are sufficient to induce the onset of infection [15].

The aim of this study was to compare polypropylene and silk suture materials in terms of bacterial adherence and clinical features, including the influence on wound healing.

METHODS

Patients

Ten healthy female patients aged 21 – 27 years, undergoing surgical extraction of two impacted third molars were included in the study. Using standard surgical protocol, unilateral upper and lower wisdom teeth have been extracted at the same time and wounds were sutured with simple interrupted sutures. The envelope design for mucoperiosteal flap was used in mandible, with sulcular incision going from mesial part of the first molar, engaging second molar and extending buccally along the external oblique ridge. In the maxilla, standard triangular flap was performed with the vertical releasing incision made at the distal part of the interdental papilla between first and second molar. Each wound was sutured with different thread (one monofilament and one multifilament) taking care of equal distribution between jaws, i.e. both threads were used 5 times in the upper and 5 times in the lower jaw. The suture materials were black braided silk (*Sofsilk®,* 4/0 gauge, with 19mm, 3/8 circle „reverse cutting" needle, *Covidien llc, USA)* and polypropylene (*Surgipro®* 4/0 gauge, with 19mm, 3/8 circle „reverse cutting" needle, *Covidien llc, USA*). All sutures were placed and removed by the same surgeon in order to avoid inter-examiner variability. Sutures were removed 7 days postoperatively. The study was approved by the institutional Ethics Committee and is in compliance with Helsinki Declaration. Accordingly, all included patients signed a detailed informed consent.

Microorganisms' Quantification

Knots of both sutures, obtained from each patient, were placed into sterile "Eppendorf" tubes, transferred to the lab and prepared for microbial analysis. In order to obtain consistent results, a portion of 4mm in length of each sample was used for real-time PCR. Bacterial DNA was isolated using a KAPA Express Extract DNA Extraction Kit (Kapa Biosystems, Wilmington, MA, USA)

according to manufacturer's instructions. DNA extracts were stored at – 20 ºC prior to PCR analysis. Total gene copy number determination was done as described by Brajović et al [16], using Maxima™ SYBR Green/ROX qPCR Master Mix (Thermo Fisher Scientific) and the following primers: Fw 5'-TCCTACGGGAGCACAGT'-3 and Rv (5'GGACTACCAGGGTATCTAATCCTGTT-3'. Real-time PCR analyses were performed on Line Gene-K Fluorescence Real-time PCR Detection System (BIOER, China).

Clinical Parameters

Control check - ups were performed on the 1st, 3rd, 7th day postoperatively. Soft tissue healing was judged by the operator with the help of healing index (HI) shown in table 1 and presented numerically [17]. Using Visual Analogue Scale (VAS), the operator rated threads with respect to easiness of intraoperative handling properties and easiness of removal. Patients, using the same scale, evaluated the suture discomfort and suture removal pain for each type of suture.

Table 1. Soft tissue healing index by Landry et al. [17].

Very poor (1) (has 2 or more of the following)	Tissue color: **≥50 % of gingiva red** Response to palpation: **bleeding** Granulation tissue: **present** Incision margin: **not epithelialized, with loss of epithelium beyond incision margin** Suppuration: **present**
Poor (2)	Tissue color: **≥50% of gingiva red** Response to palpation: **bleeding** Granulation tissue: **present** Incision margin: **not epithelialized, with connective tissue exposed**
Good (3)	Tissue color: **≥25 and <50 % of gingiva red** Response to palpation: **no bleeding** Granulation tissue: **none** Incision margin: **no connective tissue exposed**
Very good (4)	Tissue color: **<25 % of gingiva red** Response to palpation: **no bleeding** Granulation tissue: **none** Incision margin: **no connective tissue exposed**
Excellent (5)	Tissue color: **all tissues pink** Response to palpation: **no bleeding** Granulation tissue: **none** Incision margin: **no connective tissue exposed**

Scanning Electron Microscopy (EM)

Samples of both suture materials used in this study were chosen randomly and analyzed by Scanning Electron Microscopy (SEM). Specimens of silk and polypropylene were placed on specimen holders and coated with gold in a gold sputter at 18mA for 1 minute. Specimens were analyzed descriptively and photographed in a VEGA TS 5133MM SEM, high vacuum mode using the SE detector with accelerating voltage.

Statistical Analysis

All statistical analyses were done using Statistical Package for Social Science (SPSS software package, version 18.0; SPSS Inc., Chicago, IL, USA). Mean, median, SD and range were used for description of numeric data. Descriptive data were expressed as percentage for discrete measures. Categorical variables were compared using Chi Square Test (χ^2). Numeric data were analyzed using Friedman and Wilcoxon test. Spearman's correlation coefficient was done in order to assess the relationship between clinical parameters and microbial adherence. Differences were considered significant when the P value was less than 0.05.

RESULTS

Microorganisms' Quantification

A total of twenty suture samples were examined for microbial adherence and a statistically significant difference was found between the average gene copy number of bacteria on silk sutures (2.33E+10±2.60E+10SD) and polypropylene (1.46E+8±2.68E+8SD) (Figure 1). Not only the average number of bacteria on silk was higher than on polypropylene, but also all 10 silk samples, considered individually, had higher bacterial load than the corresponding polypropylene samples.

Clinical Parameters

Postoperative period was uneventful in all patients. There were no postoperative complications such as wound dehiscence, immediate or delayed infection, dry socket etc. In the present study, a better regeneration was found around polypropylene sutures than around silk sutures, both on the 3rd and 7th day postoperatively (Figure 2). No significant correlation was found between suture microbial adherence and soft tissue healing.

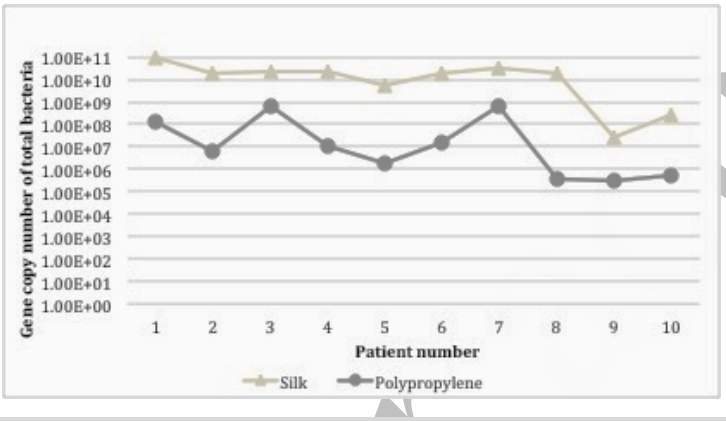

Figure 1. Individual values of total gene copy number of bacteria on silk and polypropylene sutures for each patient and type of suture (p=0.005).

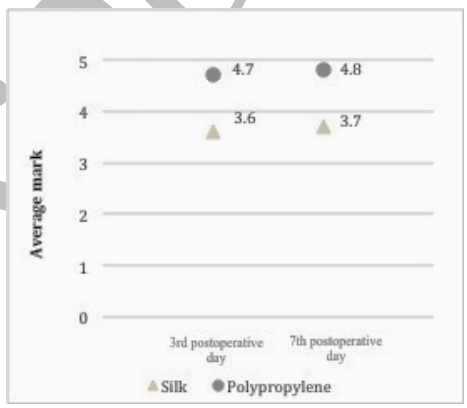

Figure 2. Average mark for each type of suture on the 3rd and 7th postoperative day according to soft tissue healing index by Landry et al. [17] (p=0.016).

Superior intraoperative handling properties were registered for polypropylene sutures (mean VAS 96.40mm ± 4.01SD) compared to silk sutures (mean VAS 60.00mm ± 17.15SD; P=0.005). Removal of both sutures was effortless and without significant difference between the two groups (Figure 3). In addition, mean values for suture removal pain data were higher for silk suture; however, it was not statistically significant (Figure 3).

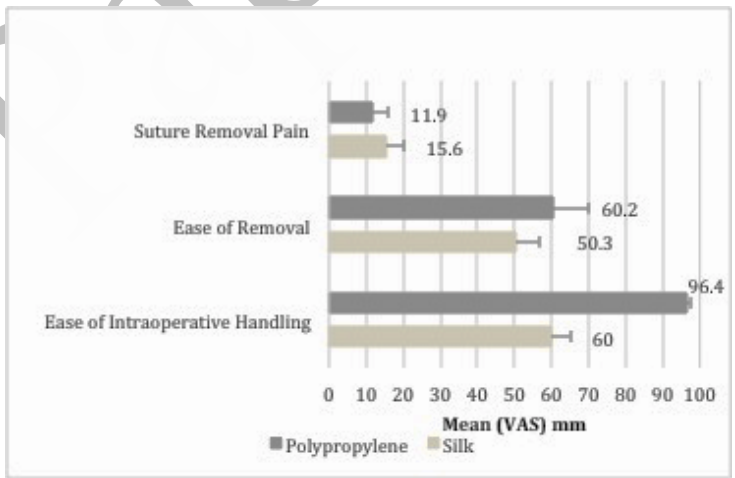

Figure 3. Visual Analogue Scale results (mean values) for clinical features related to suture materials (p=0.005).

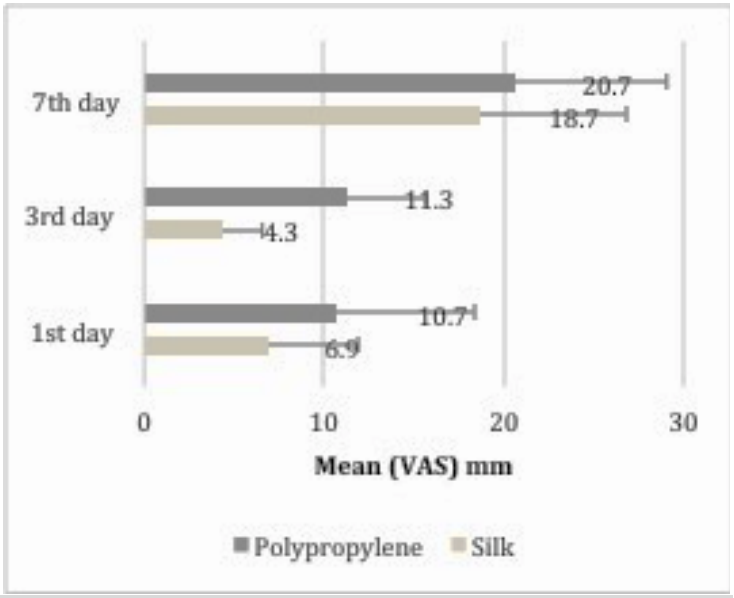

Figure 4. Visual Analogue Scale results (mean values) for patient discomfort on the 1st, 3rd and 7th postoperative day.

The degree of discomfort due to suture presence on the 1st, 3rd and 7th postoperative day, as depicted in figure 4, indicates that there was no significant difference between silk and polypropylene.

It was noted that the least mean value for discomfort was obtained on the 3rd postoperative day for both threads. In connection with that, an important correlation was found between bacterial adherence and patient discomfort for silk (r_s = 0.84; P = 0.002), whilst such an association was not found for polypropylene (r_s = 0.44; P = 0.21).

Scanning electron microscopy

Representative micrographs of silk and polypropylene threads are given in figure 5 depicting obvious differences related to debris accumulation (Figure 5).

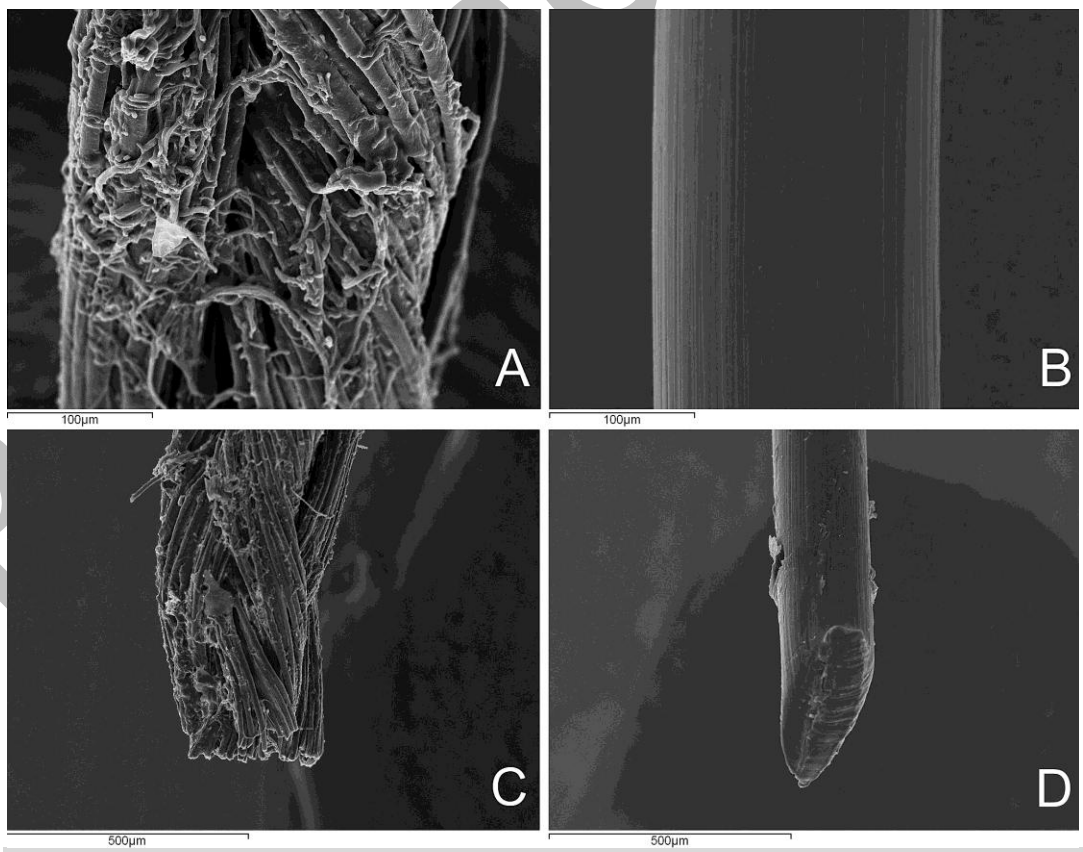

Figure 5. Scanning Electron Micrograph of: (A) silk and (B) polypropylene sample, 1mm from the free end; free end of (C) silk and (D) polypropylene.

DISCUSSION

Establishing primary wound closure without tension and avoiding postoperative infection are essential factors for optimal wound healing. Various suture materials are used in oral surgery for that purpose. One could find himself in dilemma whether to use absorbable or non-absorbable, monofilament or multifilament, natural or synthetic materials. Non-absorbable sutures are widely used in oral surgery due to their satisfactory clinical properties. On the other hand, complex suturing techniques require utilization of absorbable sutures occasionally. Absorbable materials are often indispensable in pediatric surgery to protect children from additional trauma at the time of removal. Besides, for high – risk patients (HIV, HBV, etc.), it is preferable to use absorbable sutures in order to avoid unnecessary exposition of medical staff [1].

Silk is a non-absorbable multifilament suture of natural origin, well-known as an easy handling material, very pliable and strong enough to resist breaking during surgery. What is regarded as its negative feature is a significant tensile strength loss in early postoperative days in conjunction with swelling and fragmentation due to soaking with saliva [7,18, 19, 20]. Nevertheless, necessity for longer tissue support, inevitably impose the use of non-absorbable synthetic materials as they maintain tensile strength for a long time. In the case of polypropylene, it has been shown that tensile strength is modified very little immediately after knot tying [21]. Moreover, it has also been shown on animal models that polypropylene retained its tensile strength even after a period of 2 years [11]. Additionally, polypropylene as a monofilament synthetic suture elicits less pronounced tissue reaction then multifilament sutures [11, 12]. It also has been confirmed that silk induces remarkably greater tissue reaction in comparison with monofilament synthetic sutures [5–7, 22].

To the best of our knowledge, there are no studies on patients dealing with clinical implications of polypropylene versus silk use in oral surgery. Probably, the smooth surface and absence of capillarity enables polypropylene thread not only to engage tissue with minimal friction and trauma, but also to cause less tissue irritation during the healing period. The latter is of special importance, since strong tissue reaction around a suture could impede tissue regeneration and prolong healing. Despite some limitations, the present study confirmed significantly better soft tissue healing around polypropylene sutures as compared to silk ones, both on the 3rd and 7th postoperative day.

According to the literature, greater risk of bacterial colonization and migration along the suture is related to multifilament materials due to "wicking" phenomenon and interstices between twisted/braided threads [23, 24, 25]. Consequently, microorganisms might be transferred into deeper parts of the wound where they may be harmful, causing an infection and delay of healing. However, our results showed no correlation between bacterial adherence and soft tissue healing. Quantification of bacteria by real-time PCR is reliable to a great extent, although the number of bacteria includes both viable and nonviable microbial species. The analysis of collected data in our study clearly indicates that silk suture is far more susceptible to bacterial adherence than polypropylene. These

results are in accordance with findings of other authors [20, 23, 24,26, 27, 28]. Despite different methods used for bacterial identification, data from all studies are consistent regarding the fact that monofilament sutures are less prone to microbial adherence than multifilament sutures. It is also widely accepted that physical configuration of threads, more than the material itself, contributes to different affinity of bacteria.

Concerning polypropylene features, its outstanding breaking strength, tying fluency and knot security additionally contribute to recommend it as the material of choice for surgical sutures are [21, 29]. Although sutures with low friction coefficient are at greater risk of being undone untimely, this may be successfully prevented by selecting adequate knots [1, 2]. In our study, polypropylene was estimated as highly preferable to silk due to easiness in intraoperative manipulation. Our study showed no significant difference between polypropylene and silk sutures in relation to the easiness of thread removal and accompanying removal pain (Fig. 4). Higher mean value of suture removal pain for silk suture might be a consequence of inferior healing, as well as higher friction, as compared to polypropylene. Namely, when a thread with huge friction coefficient is glided through the tissue with considerable speed, that friction could be converted into heat which ultimately may result in onset of micro-burns along the line of the suture [1]. In our study polypropylene was found to be slightly easier to remove, most likely due to its low friction rate, as well as an absence of fluid absorption.

As polypropylene is not widely used in oral surgery due to its rigidity, in particular caliber 3-0, almost all available information about this thread come from other fields of surgery. Our study showed no significant difference between silk and polypropylene sutures regarding patient discomfort, albeit values for polypropylene were higher, especially on the 1st and 3rd postoperative day. Presumably, the main reason for patient annoyance is related to pricking which could sometimes lead to appearance of decubitus in the postoperative period. In order to avoid that kind of complication, it is recommended using threads with smaller diameter (4-0, 5-0, 6-0) as well as cutting them with scissors at a right angle, thereby evading the formation of sharp free end. Likewise, leaving free ends at least 5–7mm long may contribute to improved acceptance of these sutures by reducing inflexibility and pricking effect. It can be assumed that lack of bacteria on polypropylene suture knots may compensate for their pricking effects. Hence, in our study, patient's subjective sensations of comfort/discomfort were quite similar for silk and polypropylene.

CONCLUSION

In conclusion, polypropylene suture material showed significantly lower microbial adherence and superior clinical features compared to silk, including significantly better soft tissue healing.

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