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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Microbial adherence affinity and clinical characteristics of polypropylene versus silk sutures in oral surgery

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SUMMARY

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

Methods Ten 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 – polypropylene – and one multifilament – silk suture). Stitches were removed seven days postoperatively. Real-time polymerase chain reaction was used to analyze bacterial adherence. Intraoperative handling and ease 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 silk compared to polypropylene sutures ($p = 0.005$). Superior intraoperative handling properties were registered suturing with polypropylene compared to silk ($p = 0.005$). Soft tissue healing was significantly better around polypropylene sutures, both on the third and the seventh postoperative day ($p = 0.016$). Patient discomfort was slightly higher for polypropylene sutures, 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

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. Ease 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 advancements in the field of synthetic fibers have 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 the 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.

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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 were 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 the first and the 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 five times in the upper and five times in the lower jaw. The suture materials were black braided silk (Sofsilk®, Covidien LLC, USA) 4/0 gauge, with a 19 mm, 3/8 circle "reverse cutting" needle, and polypropylene (Surgipro®, Covidien LLC) 4/0 gauge, with a 19 mm, 3/8 circle "reverse cutting" needle. All sutures were placed and removed by the same surgeon in order to avoid inter-examiner variability. The sutures were removed seven days postoperatively. The study was approved by the institutional Ethics Committee and is in compliance with the 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 tubes (Eppendorf, Hamburg, Germany), transferred to the lab, and prepared for microbial analysis. In order to obtain consistent results, a portion of 4 mm in length of each sample was used for real-time polymerase chain reaction (PCR). Bacterial DNA was isolated using a KAPA Express Extract DNA Extraction Kit (Kapa Biosystems, Wilmington, MA, USA) according to the manufacturer's instructions. DNA extracts were stored at -20°C 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, Waltham, MA, USA) 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 (Hangzhou Bioer Technology Co. Ltd., Hangzhou, China).

Clinical parameters

Control check-ups were performed on the first, third, and seventh day postoperatively. Soft tissue healing was judged by the operator with the help of healing index shown in Table 1 and presented numerically [17]. Using the Visual Analogue Scale (VAS), the operator rated threads with respect to the ease of intraoperative handling properties and the ease 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

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 18 mA for one minute. The 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 SPSS software package, version 18.0 (SPSS Inc., Chicago, IL, USA). Mean, median, SD, and range values were used for the description of numerical data. Descriptive data were expressed as percentage for discrete measures. Categorical variables were compared using the χ^2 test. Numerical 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 20 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 + 10 SD) and polypropylene (1.46 E + 8 ± 2.68E + 8 SD) (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 third and on the seventh day postoperatively (Figure 2). No significant correlation was found between suture microbial adherence and soft tissue healing.

Superior intraoperative handling properties were registered for polypropylene sutures (mean VAS 96.40 mm ± 4.01 SD) compared to silk sutures (mean VAS 60 mm ± 17.15 SD; 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).

The degree of discomfort due to suture presence on the first, third, and seventh postoperative day, as depicted in Figure 4, indicates that there was no significant difference between silk and polypropylene.

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.

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 a 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. In addition, for high-risk patients (HIV, HBV, etc.), it is preferable to use absorbable sutures in order to avoid unnecessary exposure of medical staff to pathogens [1].

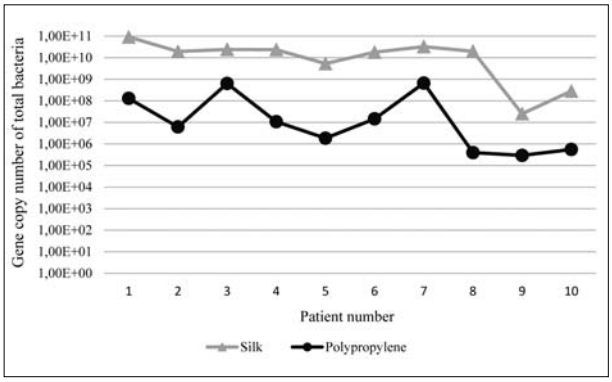

Figure 1. Individual values of total gene copy number of bacteria on silk and polypropylene sutures for each patient and type of suture (p = 0.005)

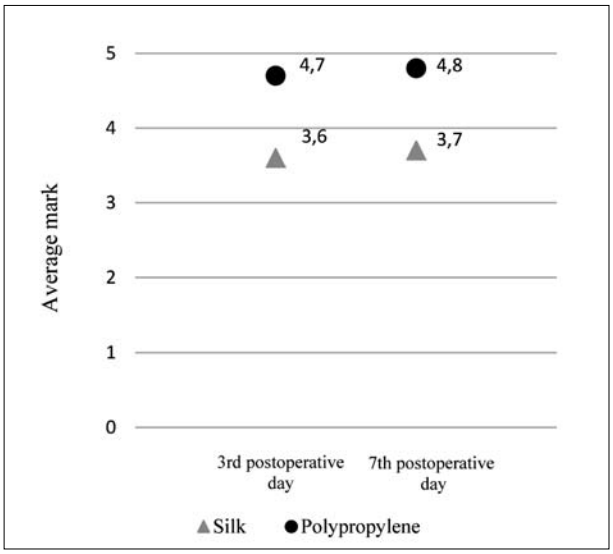

Figure 2. Average mark for each type of suture on the 3rd and 7th postoperative day according to soft tissue healing index by Landry et al. [17] (p = 0.016)

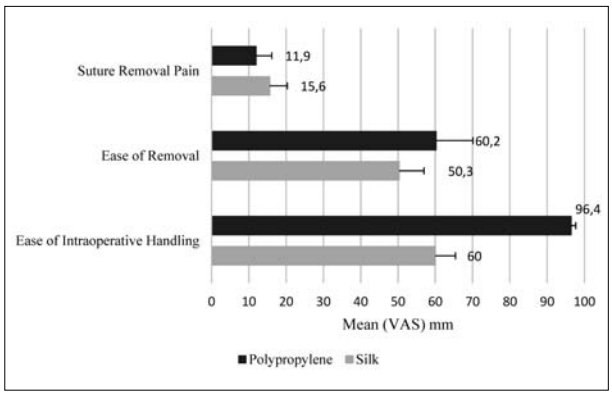

Figure 3. Visual Analogue Scale results (mean values) for clinical features related to suture materials

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

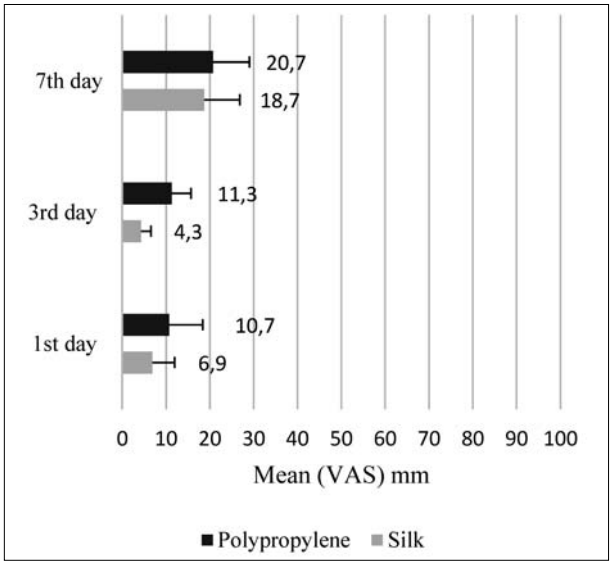

Figure 4. Visual Analogue Scale (VAS) results (mean values) for patient discomfort on the 1st, 3rd, and 7th postoperative day

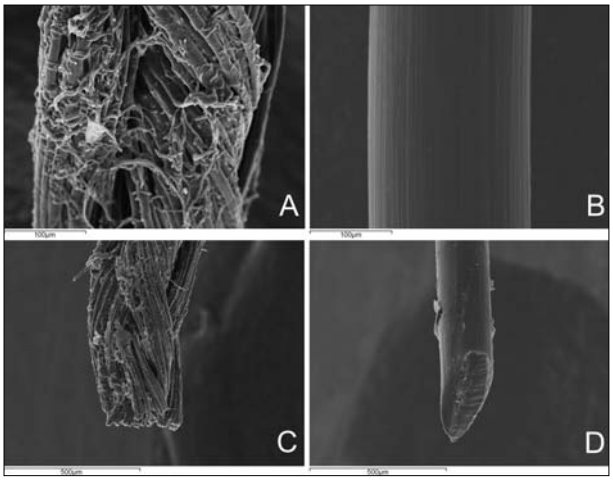

Figure 5. Scanning electron micrograph of (A) silk and (B) polypropylene sample, 1 mm from the free end; free end of (C) silk and (D) polypropylene

with saliva [7, 18, 19, 20]. Nevertheless, the necessity for longer tissue support inevitably imposes 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 two years [11]. Additionally, polypropylene as a monofilament synthetic suture elicits less pronounced tissue reaction then multifilament sutures [11, 12]. It has also 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. It may be that the smooth surface and the absence of capillarity enable polypropylene thread to not only 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, on both the third and the seventh 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 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 recommend it as the material of choice for surgical sutures [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 (Figure 3). 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 tissue with considerable speed, that friction is converted into heat, which ultimately may result in the 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 comes 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 first and the third postoperative day. Presumably, the main reason for patient annoyance is related to pricking, which could sometimes lead to the appear-

ance of decubitus in the postoperative period. In order to avoid that kind of complication, it is recommended to use threads with smaller diameter (4-0, 5-0, 6-0), as well as to cut them with scissors at a right angle, thereby evading the formation of a sharp free end. Likewise, leaving free ends at least 5–7 mm long may contribute to improved acceptance of these sutures by reducing inflexibility and pricking effect. It can be assumed that the lack of bacteria on polypropylene suture knots may compensate for their pricking effect. Hence, in our study, patient's subjective sensations of comfort/discomfort were quite similar for silk and polypropylene.

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

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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 десет здравих испитаника код којих су хируршки извађени 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*