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ORIGINAL RESEARCH

EFFECTS OF DIFFERENT SUTURE MATERIALS ON TISSUE HEALING

Farklı Dikiş Materyallerinin Doku İyileşmesi Üzerindeki Etkileri

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ABSTRACT

Purpose: *The purpose of this study was to investigate the healing differences in between four different widely used suture materials in the oral surgery practice, including silk (Perma-Hand; Ethicon, INC., Somerville, NJ, USA), polypropylene (Prolene; Ethicon, INC., Somerville, NJ, USA), coated polyglactin 910 (Ethicon, INC., Somerville, NJ, USA). and polyglecaprone 25 (Ethicon, INC., Somerville, NJ, USA).* ***Materials and Methods:*** *20 male rats were randomly allocated into two groups depending on their sacrification days (post-operative 1st and the 7th days). Four longitudinal incision wounds, each 1cm in size, were created on the dorsum of each animal which were then primarily closed with four different types of sutures.* ***Results:*** *The effects of these suture materials on soft tissue healing were compared histopathologically, by means of density of the cells, necrosis, fibrosis, foreign body reaction, the presence of cells of acute and chronic infection. No statistically significant difference was observed between the groups regarding the density of the cells, necrosis, fibrosis, foreign body reaction, and the presence of the cells of acute & chronic infections. Of note, propylene showed slightly less tissue reaction among the other materials.* ***Conclusion:*** *The results of our study showed that there is no only one ideal suture material for surgical practice. The factors related to the patient, the type of the surgery and the quality of the tissue are important to decide an appropriate suture material.*

Keywords: *Suture material; soft tissue healing; surgery; dorsum; rat*

ÖZ

Amaç: *Bu çalışmanın amacı oral cerrahi işlemlerde sıklıkla kullanılan 4 farklı dikiş materyalinin (ipek, polipropilen, poliglaktin 910, poligilekapron 25) yumuşak doku iyileşmesi üzerindeki etkilerini incelemektir.*

Gereç ve Yöntem: *Bu çalışmada 20 adet Sprague-Dawley cinsi sıçan kullanılmıştır. Rastgele oluşturulan eşit sayıdaki gruplardaki deney hayvanlarında dorsum bölgesinde dört adet 1 cm uzunluğunda kesi yapılmış ve cerrahi yaralar 4 farklı dikiş materyali ile primer olarak kapatılmıştır. Deney hayvanları post operatif 1. ve 7. günlerde sakrifiye edilmiştir.*

Bulgular: *Dikiş materyallerinin yumuşak doku iyileşmesi üzerindeki etkileri elde edilen histopatolojik kesitlerde hücre yoğunluğu, nekroz varlığı, fibrozis, yabancı cisim reaksiyonu, akut ve kronik enfeksiyon hücrelerinin varlığı yönünden incelenmiştir. Gruplar arasında hücre yoğunluğu, nekroz varlığı, fibrozis, yabancı cisim reaksiyonu, akut ve kronik enfeksiyon hücrelerinin varlığı bakından istatistisel olarak anlamlılık gözlenmemiştir. Ancak, propilen grubunda diğer materyallere göre daha az doku reaksiyonu olduğu izlenmiştir.*

Sonuç: *Çalışmamızın sonuçları cerrahi pratiğinde tek bir ideal sütür materyali olmadığını göstermiştir. Hastaya bağlı faktörler, cerahinin tipi, dokunun kalitesi ideal materyal seçiminde göz önünde bulundurulmalıdır.*

Anahtar kelimeler: *Dikiş materyali; yumuşak doku materyali; cerrahi; dorsum; sıçan*

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Introduction

Wound repair is a well orchestrated and highly coordinated process that includes a series of overlapping phases: inflammation, cell proliferation, matrix deposition, and tissue remodelling (1). Sutures serve to maintain tissue approximation until the wound attains sufficient tensional strength to prevent dehiscence. Correct closure and stabilization of surgical wound margins influence the success of the surgical procedure (2).Sutures used in the oral and maxillofacial surgery practice behave according to the quality of the tissues involved, presence of saliva and specific microbiota. They represent a pathway communicating the internal and external regions of the tissues, influencing the quality of wound healing. The high level of vascularization and functions as masticatory, phonetic and respiratory render the oral cavity a unique district. It has been mentioned that rather than factors related to suture materials and different surgical techniques, and with the exception of surgeon's experience, general characteristics of the patients (i.e., gender and age) and of the wounds (i.e., length and site) seemed to be the two primary risk factors responsible for local wound complications. A good suture material must neither interfere with the cellular proliferation nor with the connective tissue organization (3).

An ideal suture is strong, handled easily, and forms secure knots. It causes minimal tissue inflammation and does not promote infection. It stretches and accommodates wound edema. Although no single suture possesses all of these features together, proper selection of sutures helps achieve better results. Proper suturing technique is essential for obtaining good cosmetic results and avoiding scarring and poor wound healing (4, 5). The aforementioned factors can be controlled and be improved to provide a near-ideal situation; however, the search for a so-called ideal suturing material is ongoing. An ideal suturing material will obviously depend on the clinical situation for which it is needed. Qualities like adequate approximation, support and low immunogenicity are important and define a so-called ideal suture material (6). In the present study, four different suture materials were used:

Polyglecaprone 25 is an absorbable, synthetic, monofilament suturing material which has a tensile strength of 21 days and an absorption profile of 90-120 days (6). Silk is a non-absorbable, natural, braided material that is preferred by some surgeons because it is easy to handle; it has good tension and stability for the duration of suture (7). On the other hand, the braided nature of the silk suture allows surface debris and bacterial accumulation, resulting in inflammation of the surrounding wound (8). Polypropylene suture (Prolene, Ethicon, INC., Somerville, NJ, USA) is a synthetic non-absorbable monofilament and has a high tensile strength. Coated Polyglactin 910 (Ethicon, INC., Somerville, NJ, USA) is a synthetic absorbable braided coated suture composed of a copolymer made of 90% glycolide and 10% l-lactide (9).

Delayed healing might result from inflammatory reactions caused by the suture materials themselves. Therefore, tissue reaction to these materials is one of the crucial factors in choosing the best material for the task at hand from a wide variety of suture materials (8, 9). The purpose of the present study is to compare the soft tissue reactions induced by these four different suture materials commonly used in oral and maxillofacial surgery practice.

Materials and Methods

Animal care and study groups

The experimental protocol and guidelines for the care and use of the laboratory animals were approved by the Institutional Animal Care and Ethics Committee of Istanbul University Institute for Experimental Medical Research (number:196/01.12.2010). 20 male Sprague–Dawley rats aged 12 months, mean (SD) weight 340±20g obtained from Istanbul University Institute for Experimental Medical Research, were used. The rats were randomly allocated into two groups depending on their sacrification days (post-operative 1st and 7th days). Ten animals were used for each group. Animals were housed individually in a special clear sided cages at controlled temperature and humidity (23-24º C; 50%) with a 12:12-h light:dark cycle. The cage size was 250 cm^2 for each rat. They were made of transparent polycarbonate solid tubs. The rats received food, sterile water provided *ad libitum* throughout the study.

Surgical procedure

Animals were operated under general anaesthesia induced with ketamine (70 mg/kg) given intraperitoneally. The dorsal skins of the animals were shaved, washed with sterile saline solution and disinfected with 5% iodine. (Figure 1)

Figure 1. *The preoperative view of the operation site.*

A 1-cm longitudinal skin incision was performed with a no.15 blade. Two cm of distance was created between skin incision lines. The defect site was washed with sterile saline solution. The wound was then closed primarily with a standard technique, using two turn clock-wise and one anticlock-wise knots. All procedures were performed by the same surgeon. Each rat received four dorsal defects in which each one was sutured by one of the four different suture materials which were silk, polypropylene, braided-coated polyglactin 910, and polyglecaprone 25. (Figure 2)

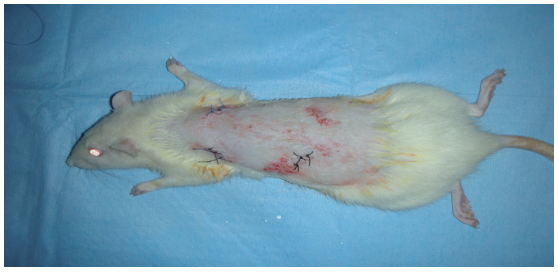

Figure 2. *The view of the incisions sutured by four different materials.*

All suture materials were size 3-0. Before the histopathological investigation, a code was allocated to each defect site, to blind the pathologists. Excisional biopsies were performed at 1st and 7th days after the initial surgical procedure. (Figure 3)

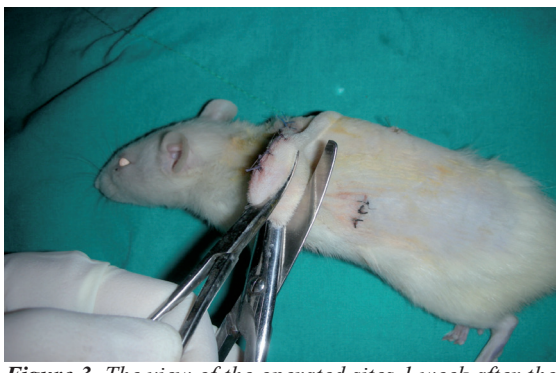

Figure 3. *The view of the operated sites 1 week after the operation, before harvesting.*

Tissue specimens were fixed in 10% formalin and were transferred to Istanbul University, Faculty of Medicine, Department of Pathology, for the histopathological evaluations.

Post-operative care

Ringer's lactate solution was given subcutaneously; antibiotic (cefazolin, 10 mg/kg) and analgesic (buprenorphine, 0.05 mg/kg) were given intraperitoneally for 2 days post-operativeley.

Histopathological assessment

The specimens were fixed in 10% neutral buffered formalin for during 24 hours. After fixation and tissue processing they were embedded in paraffin and serial sections of 2-4 µm thicknesses were cut and stained with hematoxylin and eosin (HE), for histopathological evaluation under a light microscope. The density of the cells, necrosis, fibrosis, foreign body reaction, the presence of the cells of acute and chronic infection are investigated. The findings were categorized as follows: - indicates none, + (25-50%) as slight, ++ (50- 75%) as moderate, and +++ (75-100%) was scored as advanced (10).

Statistical analysis

The statistical analysis was aided by NCSS program (Number Cruncher Statistical System) 2007 Statistical Software (Utah, USA). Chi-square test was used for the qualitative data. P values less than 0.05 were considered as statistically significant.

Results

No complications were observed during the experimental period including any needle fractures, suture losses or wound dehiscences. Clinically, manipulation of silk and coated polyglactin 910 were found to be superior than polyglecaprone 25. Table 1 demonstrates all the statistical data. No statistically significant difference was observed between the coated polyglactin 910, polypropylene, silk and polyglecaprone 25 regarding the cell density at the 1st day and at the 7th day (P=0.828; P=0.639)

Table 1. *Comparison of the groups regarding the cell density, necrosis, fibrosis, acute cell, chronic cell and foreign body reaction and the comparison of the each group at the 1st and 7th days.*

			Polyglactin 910		Polypropylene		Silk		Polyglecaprone 25		
Cell density	1st day	(-)	3	30%	2	20%	2	20%	2	20%	
		(+)	1	10%	3	30%	4	40%	2	20%	
		(++)	5	50%	4	40%	3	30%	3	30%	
		(+++)	1	10%	1	10%	1	10%	3	30%	p=0.828
	7 th day	(+)	0	0%	2	20%	1	10%	2	20%	
		(++)	4	40%	5	50%	6	60%	4	40%	
		(+++)	6	60%	3	30%	3	30%	4	40%	p=0.639
			p=0.053		p=0.346		p=0.122		p=0.515		
Necrosis	1st day	(-)	10	100%	9	90%	10	100%	10	100%	
		(+)	0	0%	1	10%	0	0%	0	0%	p=0.380
	7th day	(-)	10	100%	10	100%	10	100%	10	100%	
			p=0.305		-		-		-		
Fibrosis	1 st day	(-)	10	100%	10	100%	10	100%	10	100%	
		(+)	0	0%	0	0%	1	10%	2	20%	
	7th day	(++)	9	90%	10	100%	9	90%	8	80%	
		(+++)	1	10%	0	0%	0	0%	0	0%	p=0.331
			P<0.05		P<0.05		P<0.05		P<0.05		
Acute cell	1st day	(+)	4	40%	5	50%	6	60%	4	40%	
		(++)	5	50%	4	40%	3	30%	3	30%	
		(+++)	1	10%	1	10%	1	10%	3	30%	p=0.769
	7th day	(-)	8	80%	7	70%	8	80%	9	90%	
		(+)	2	20%	2	20%	2	20%	1	10%	
		(++)	0	0%	1	10%	0	0%	0	0%	p=0.720
			p=0.002		p=0.011		p=0.003		P<0.05		
Chronic cell	1st day	(-)	3	30%	2	20%	2	20%	2	20%	
		(+)	1	10%	4	40%	4	40%	2	20%	
		(++)	5	50%	4	40%	3	30%	3	30%	
		(+++)	1	10%	0	0%	1	10%	3	30%	p=0,604
	7 thday	(+)	0	0%	0	0%	0	0%	2	20%	
		(++)	6	60%	7	70%	8	80%	4	40%	
		(+++)	4	40%	3	30%	2	20%	4	40%	p=0,221
			p=0.117		p=0.020		p=0.035		p=0.515		
Foreign body reaction	1st day	(-)	10	100%	10	100%	10	100%	10	100%	
		(+)	7	70%	9	90%	6	60%	7	70%	
	7th day	(++)	0	0%	1	10%	0	0%	1	10%	
		(+++)	3	30%	0	0%	4	40%	2	20%	p=0.365
			P<0.05		P<0.05		P<0.05		P<0.05		

**The numbers which were highlighted, demonstrate that the difference is statistically significant (P<0.05 significant).*

No statistically significant difference was observed between the coated polyglactin 910, polypropylene, silk and polyglecaprone 25, regarding the presence of cells of chronic infection on the 1st post-operative day and the 7th post-operative day (P=0.604; P=0.221). No statistically significant difference was observed between the 1st and the 7th post-operative days in coated polyglactin 910 and polyglecaprone 25 groups regarding the presence of the cells of chronic infection (P=0.117;P P=0.515) (Figure 4). In the polypropylene and silk groups however, the presence of cells of chronic infection was found to be statistically higher at the7th day compared to the 1th post-operative day (P=0.020; P=0.035).

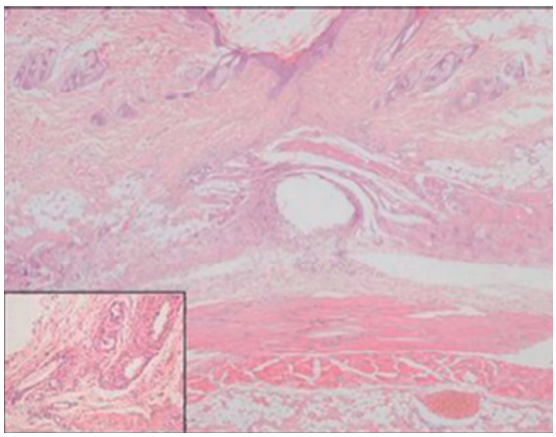

Figure 4. *Dense inflammatory infiltration around the coated polyglactin 910 suture material. Note the giant cell and foreign body reactions. (Haematoxylin and eosin, original magnification 40 X) Inset: Dense foreign body and giant cell. (Haematoxylin and eosin, original magnification 200X).*

No statistically significant difference was observed between the coated polyglactin 910, polypropylene, silk and polyglecaprone 25 regarding the presence of necrosis on the first post-operative day (P=0.380). The presence of necrosis was found as negative in all groups at the 7th post-operative day. Additionally, no statistically significant difference was observed between the 1st and 7th day regarding the presence of necrosis in the prolene group (P=0.305). Fibrosis was found as negative in all groups at the 1th post-operative day. On the 7th post-operative day, no statistically significant difference was observed between the coated polyglactin 910, polypropylene, silk and polyglecaprone 25 groups regarding the presence of fibrosis (P=0.331) Figure 5. In all groups, the presence of fibrosis was found as statistically higher at the7th post-operative day compared to 1st post-operative day ($P<0.05$; $P<0.05$; $P<0.05$; $P<0.05$).

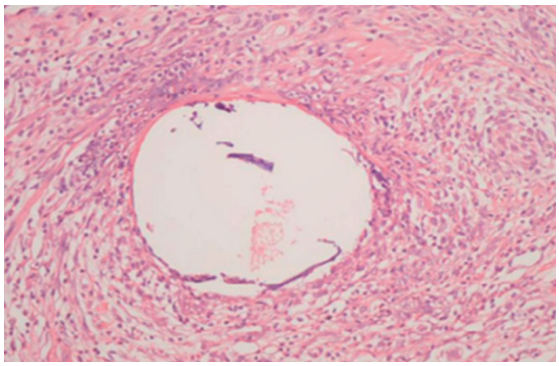

Figure 5. *Histological section from the polypropylene group. Inflammatory infiltration and dense fibrosis around the polypropylene group suture material (Haematoxylin and eosin, original magnification 100 X).*

No statistically significant difference was observed between the coated polyglactin 910, polypropylene, silk and polyglecaprone 25 groups regarding the presence of cells of acute infection on the 1st and 7th days post-operatively (P=0.769; P=0.720). In all groups, the presence of cells of acute infection was found to be statistically higher at the7th post-operative day compared to the 1st post-operative day (P=0.002; P=0.011; P=0.003; P=0.001). The presence of foreign body reaction was found to be negative in all groups at 1st post-operative day. In all groups, the presence of foreign body reaction was found to be statistically higher at the7th post-operative day compared to the 1st post-operative day (P=0.0001; P=0.0001; P=0.0001; P=0.0001)**.** (Figure 6 and 7) There was no statistically significant difference in between groups at the 7th post-operative day (P=0.365).

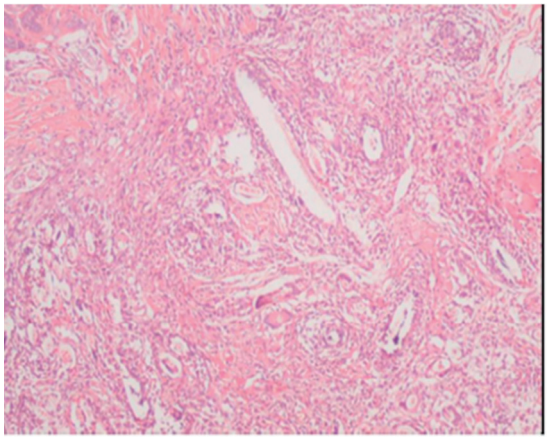

Figure 6. *Histological section from the silk group. Dense foreign body reaction. (Haematoxylin and eosin, original magnification 100 X).*

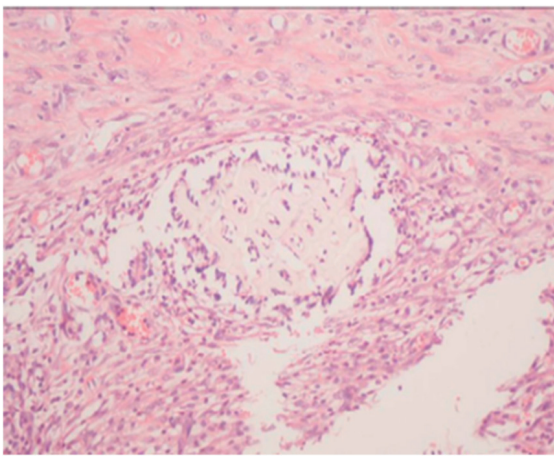

Figure 7. *Histological section from the polyglecaprone 25 group. Dense foreign body reaction. (Haematoxylin and eosin, original magnification 200 X).*

Histopathological analysis

At first day after surgery, no significant difference was observed in the samples regarding the inflammation and the type of the inflammatory cells. Although, polymorphonuclear leucocytes were dominant, mononuclear cells were also observed. Inflammatory cells were commonly found in the area of the lesion. On the other hand, they were also found in muscle and facsia layers in some of the samples. Necrosis and foreign body reaction were not observed in any samples. At 7th day; chronic inflammation was dominant in the samples, unlike the first day samples. In some of the samples, polymorphonuclear leucocytes were lower. Besides this, diffuse polymorphonuclear leucocyte areas were observed showing similarities with abscess formation in a few samples. Although the inflammatory cells were commonly found in the area of the lesion, they were also infiltrated into deeper tissues too. In striated muscles, degenerative and regenerative alterations characterized with multinuclear cells and intracytoplasmic pale eosinophylic inclusion, were observed.

Fibrosis was present in similar manner in all samples. Necrosis was not observed in any samples. In all samples, foreign body reaction was found. Polypropylene showed less foreign body reaction. Only in polypropylene group, severe foreign body reaction was not observed.

Discussion

The limitation of this study can be determined as that it is performed on rat dorsum instead of oral mucosa. On the other hand the dorsum was choosed because it was more convenient to evaluate the suture in the dorsum. There was the possibility the damage of sutures in the mouth of the rats because of nibbling.

A period of seven days was selected as the experimental interval because it is the time period mostly preferred for suture removal in routine intraoral surgery (8). Limited foreign body reaction can be tolerated however, suture materials may sometimes lead to complex and severe tissue reactions (1). It has been well established that the presence of suture material inside the tissue increases the risk for infection, a phenomenon that is more pronounced with multifilament materials. Several studies have demonstrated and confirmed a reduced inflammatory response after the application of monofilament suture materials in oral wounds compared to multifilament ones. Multifilament sutures may promote bacterial adherence to other sterile areas by capillary action, thereby enhancing the infection process. However, many clinicians prefer the multifilaments because the monofilaments are more difficult to manipulate and have sharp ends that irritate the oral tissues (3, 11, 12). It is also reported that wound infection depends on suture material and its structure, but is not necessarily related to mono- or multifilament composition (2, 13). Several papers have been published about the bacterial colonization on the suture materials.

Otten *et al.*(14) compared the bacterial colonization of absorbable monofilament Monocryl (Ethicon, Norderstedt, Germany) and non-absorbable monofilament Deknalon (Deknatel, Genzyme GmbH, Lubeck, Germany) sutures in 11 patiens who has undergone dental surgeries. They reported that a greater number of pathogens were found on Deknalon suture. Banche et al, similarly, reported that the microbial load was significantly lower in absorbable monocryl (Johnson & Johnson Intl) when compared to non-absorbable multifilament sutures reported as Supramid (B. Braun, Melsungen, Germany), Synthofil (B. Braun, Aesculap, Bethlehem, PA, Ethibond Excel), Ti-cron (Sherwood, Davis & Geck, Danbury, CT) (15). Bacterial colonization was not in the scope of this study so it is not possible to make a proper evaluation on this, however regarding the inflammatory cell density and foreign body reactions, polyglecaprone 25 does not seem to have significant advantages in comparison with the other suture materials. On the other hand, severe foreign body reaction was observed slightly higher in silk and polyglactin 910 (multifilament sutures) in comparison to polyglecaprone 25 and polypropylene (monofilament sutures). As an advantage, polypropylene which is a non-absorbable synthetic monofilament suture, did not show severe foreign body reaction at the post-operative 7th day. These results were found to be consistent with the literature suggesting monofilament sutures showing less tissue reaction (8, 12). In oral surgery, either absorbable or non-absorbable suture materials may be used (13, 16).

Absorbable sutures offer several advantages in clinical practice, including avoiding the patient's discomfort of having sutures removed and the inconvenience of an additional visit to the clinic (17, 18). Absorbable sutures, because of their metabolism that includes enzymatic digestion and phagocytosis, may cause a greater degree of inflammation in contrast

to non-absorbable materials that produce only a blind inflammatory response (13, 16). In the present study**,** no significant difference was observed between the absorbable and non-absorbable materials. In non-absorbable suture groups such as polypropylene and silk, the presence of the cells of chronic infection was found to be statistically significant at the 7th post-operative day compared to the 1st post-operative day Polyglecaprone 25, as an absorbable suture, showed slightly higher acute infection at the 1st post-operative day. Otten et al, recommended that the sutures should be removed as early as possible after the surgery, independent from the suture being absorbable or not**.** The explanation for this recommendation was the continual contact within the complex oral flora (14).

Kim *et al.(11)*, reported that due to the oral conditions of moisture and susceptibility to infection by saliva, ingested food, microorganisms, etc., a suture placed in an oral cavity is affected differently than a suture material placed in extraoral conditions (11, 17). In our study, only skin wounds were evaluated with no oral mucosa wounds; therefore, this can be considered as a limitation of our study due to the previously mentioned literature knowledge above.

Conclusion

There were no significant complications during and post-operatively regarding the suture materials" Polypropylene as being a non-absorbable monofilament suture showed slightly less foreign body reaction. In the deciding the appropriate suture material to be used in the oral surgical procedures, all the factors related to the patient, the type of the surgery and the tissue being handled would help achieve better results. The authors determined that there is a need of more clinical and experimental studies which evaluate various suture materials in oral surgery practice.

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Conflict of interest
None declared.

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