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The sutures in dentistry

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Abstract. – In oral surgery, the last phase of a surgical operation is represented by the tissues suture, that allows the wound lips edges approximation and their stabilization, to promote haemostasis, to avoid the alimentary residues accumulation on the incision line and allow the first intention healing.

A good suture avoids that the displacing forces generated by the muscular insertions, functional movements and by the external agents destabilize or cause the surgical wound deiscence.

The purpose of this study was to re-examine the suture threads characteristics, properties and biological interactions evaluating the different studies published in literature results and conclusions.

In conclusion, the authors recommended the use of the different suture threads on the dependence of the oral surgery operation type that must be performed, of the patient compliance and of the various suture materials physical and biocompatibility characteristics.

Key Words:

Oral surgery, Suture materials, Wound healing, Bacterial adhesion.

Introduction

The suture indicates the repairing surgical act that allows to approximate the wound edges, keeping them united until the healing process will confer to the same wound the intrinsic force sufficient to maintain itself, without the necessity of a mechanical support[1] (Figures 1-4). Moreover, the surgical suture, isolating the healing centre, promotes the cicatrization process, controls the haemostasis, stabilizes the tissues on the requested position, has an opening function (Figure 5), it protects the wound by an external contamination and improves the patient comfort. For this reason, although it represents the conclusive phase of a surgical operation, it is not less important.

The wounds suture has old origins: the first description was found in a sixteenth century b.C. papyrus. They are works of the Greek doctor Hyppocrates the first traumatology texts that expounded the necessary rules for the treatment and for the wounds suture. In 1897, Joseph Lister points out that the threads sterilization with carbolic acid avoided the bacterial growth on them and so avoided the consequent tissues inflammation; a problem to take in examination on the post-operative course, because represents the main cause of surgical wounds healing delay.

The aim of this study is to re-examine and to summarize the different suture threads origin and characteristics and also their interaction on the tissues, to facilitate their use and obtain a better wound healing.

Figure 1. A monofilament suture.

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Figure 2. A monofilament suture (polyamide).

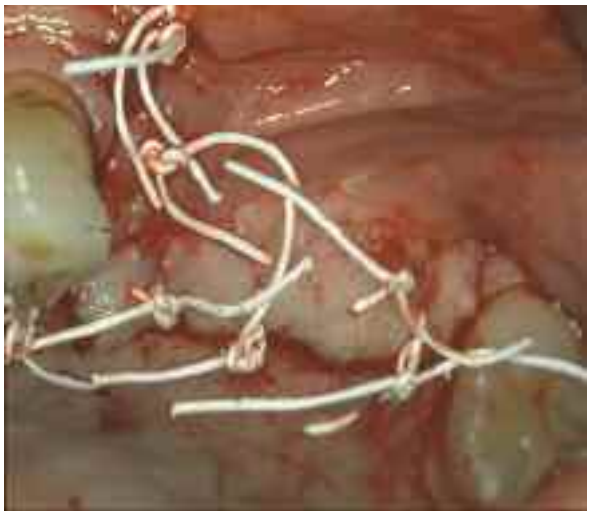

Figure 4. A monofilament suture.

Healing Modalities of a Surgical Wound

Is suitable, before taking in examination the argument in detail, to understand how the different sutures can interact with the repairing processes, know the healing modalities of a wound:

– **For first intention:** when the wound edges are approximated; is a characteristic of the surgical wounds without substance loss, non complicated by haematomas, necrosis and infections. A wound heals for first intention when is sufficient only the edges cicatrization. That happens when the diastasis is minimal and the edges were surgically approximated (suture). The scar that results is, whatever, an in defect healing modality, because the substance loss is substituted by connective tissue deprived by the same characteristics of the original tissue. So, how more precise and linear will be the surgical wound, more accurate will be the edges suture and more minimal will be these effects.
– **For second intention:** is the case of the more extended that deep wounds, how is in the scalds or with main substance loss how in the residual abscessual cavities, in the wide surgical excisions or in the wounds with irregular ragged edges, with the presence of necrotic areas, but especially when they are not cleaned. In these cases the lips are not sutured

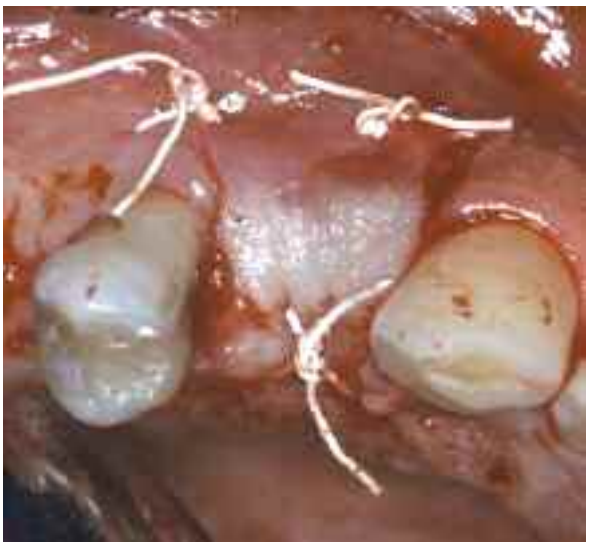

Figure 3. Surgical wound edges approximation by a monofilament suture.

Figure 5. Tissues stabilization in the requested position with opening silk sutures.

and the healing process will begin from the bottom of the wound with a granulation tissue that will proceed standing out until reaching the surface. It is a very slow modality, and requests continual medications.

– **For third intention:** is the case of the wounds destinated to a second intention healing, but thanks to a detersion an edges regularization and to the suture, is obtained a faster healing by first intention. An example is represented by some surgical wounds normally sutured, but infected in the post-operative course. In these cases the wounds must be re-opened and so leaved until the infection resolution. In that moment are re-sutured to allow a faster cicatrization. The third intention healing is, so, a particular healing modality that cames "piloted" by a surgical correcting act: aggression of the wound, that healed slowly, with a second intention followed by the edges approximation and their suture.

In the first intention healing, during the first days, the inflammatory response of the organism immunitary defence provokes an exudate formation, the acummulation of cells, fibroblasts and a high vascularization to the wound. This is the acute inflammatory phase, that lasts aproximmately five days.

The leucocytes and the other cells produce protective enzymes to destroy the damaged tissue and to remove the detritus.

After that, the detritus removal process is in an advanced phase, the fibroblasts begin to proliferate and to produce collagen fibres in the wound and, near them, proliferate also the endoteli. This is the fibroplasia phase, that lasts from the fifth to the fourteenth day approximately.

To this phase follows the collagen maturation phase and the gradual fibroblasts and just formed capillaries reduction; at the same time happens the gradual covering epithelium regeneration and migration. This phase is said of maturation and lasts until the sixth week. This type of healing is the more hoped because happens in few days and allows the re-establishment of a good tissues functional and aesthetic architecture.

In the wounds in which we have a high or a very high substance loss, the repair proceeds slowly from the bottom and on the edges, with a rich blood vessels neoformation and a high fibroblastic activity (granulation tissue). In this phase, the wound assumes a plague. The granulation tissue is comparable with an embryonic connective tissue: is rich in blood vessels, so appears with a red colour, is provided of cells with phagocytaire capacity, so resists to the pathogen germs attack.

In the first days prevail the neutrophil leucocytes for the antibacterial defence, then turn up the macrophages to clean the zone by the necrotic substances, finally arrive the fibroblasts that produce the repair connective.

A wound second intention healing is very slow and depends by the extension, the general state of the patient and by the inflammation. This repair modality happens, so, with the wound contraction and not with the primary union of the lips.

So, the three healing processes are distinguished mainly under the quantitative aspect than the qualitative one, because a more extensive tissue loss determine the formation of a scar with major dimensions and a more extended healing.

This is the reason because the suture, facilitating the lip edges reapproximation, facilitates the first intention healing process.

Characteristics and Classification of Suture Threads

Dependently of the materials used for the production of the suture surgical threads, these can be classified in natural and synthetics, on the base of their origin, in absorbable and nonresorbable sutures, on the base of their biological behaviour and finally, on the base of their structure (Figures 6-7), in monofilament (Figures 8-9), multifilament and pseudo-monofilament.

The sutures of natural origin are classified in animal origin, as the catgut and the silk, vegetal origin, as the linen and the cotton, and minerals,

Figure 6. Commercial formulation of suture threads for oral surgery operations.

Figure 7. Monofilament suture with the tissue healing at 15 days after a implant surgery with autologue bone graft, drew in the symphisis region.

Figure 9. Surgical knot in a multifilament suture (polyester) executed on a simulator.

the metals.

The sutures of synthetic origin derive from the glycolic acid, the galactic acid, the polyamides as the nylon, the polyesters, the polymers that derive from vinyl, as the ethylene and the propylene.

Based on the capacity to loss the tensile strength, the natural and the synthetic threads are divided in *absorbables*, characterized by a complete degradation until 60 days, and *nonresorbables*.

Belong to the first group (absorbable threads) the catgut, the collagen, the glycolic acid and the galactic acid. Belong to the second group (nonresorbable threads) the silk, the cotton, the linen, the metals, the polyamides, the polyesters, the polypropylene, the polytetrafluoroethylene (PTFE), better known with the name GORE-TEX. The reabsoption happens, if the threads are natural, with the action of lymphocytes and macrophages; if the threads are synthetic the reabsorption happens with a hydrolytic scission of the polymeric chain.

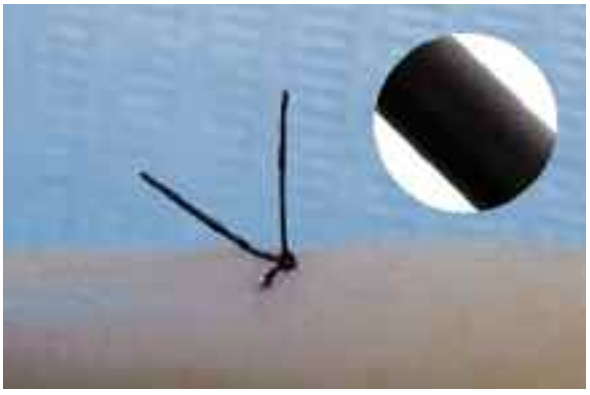

Figure 8. Surgical knot in a monofilament suture executed on a simulator.

The ideal suture must be suitable to every type of operation, easy to handle and practice, with a high resistance, sterile, without contraction, able to form a small and solid knot, to induce a minimal tissue reaction, must be not electrolytic, capillary, thrombogenic and able to induce allergic reactions, must not create a favourable situation with the bacterial growth and must reabsorb itself when its function is finished, with the minimal tissue reaction and in the less time possible. Unfortunately, a suture that have all this characteristics doesn't exists.

Examining the suture characteristics, these can be divided in biological and physical.

Biological Characteristics

Reabsorption ability: the thread degradation capacity in the tissue; in the synthetic polymers this happens with hydrolysis.

Sterility: is guaranteed by various tecniques that provide the use of the ethylene oxide or cobalt 60, the gamma rays.

Tolerability: the thread capacity to induce the minimal tissue inflammatory reaction. Unfortunately no material is characterized by a biological inertia, but behaving as a foreign body determines an inflammatory process more or less emphasized. Based on the material used, the maximum reaction is represented by the catgut, to decrease with the silk, the cotton, the linen, the polyesters, the polyamides, the absorbable synthetic materials, the polypropylene, the steel and

the titanium.

Physical Characteristics

Resistance: the thread capacity to oppose to a traction strength applied on the ends and measured to the level of a simple knot. The materials with great resistance are: the steel, the synthetic and the natural threads. On the contrary, the resistance characterizes the catgut, the silk, the polypropylene, the polyglycolic acid, the nylon, the polyester and the steel.

Capillarity: a fluid property of spread along a tube with small calibre in any direction, so also against the force of gravity. Reported to the suture, it corresponds to the absorption capacity of the liquid that the thread portion immersed in a liquid is able to provide to the dry portion.

Hydrophilia: distinguished by the capillarity, the hydrophilia represents the chemical affinity that a suture has toward the liquid molecules as, for example, the water.

Flexibility: the adaptability of a suture material, that is the ability that a thread has to fold or to twist itself without breaking. The flexibility must not be confused with the plasticity and the elasticity.

Plasticity: ability of a thread to maintain a new shape.

Elasticity: ability of a thread to become longer and to return to the original length.

Manoeuvrability: it represents the suture ductility, that is the facility in maneuvering and knotting it; therefore it appears correlated with the fluency.

Fluency: ability of a thread to proceed fluidly and without difficulty inside the tissue; it depends by the smoothness and by the suture friction coefficient, so from its structure; the monofilaments are, generally, more flowable than the multifilaments.

Length and calibre: they influence the thread manoeuvrability. Various lengths of thread exist: from 30 to 90 cm. The calibre is expressed in millimeters, according to the European pharmacopoeia, or in number of zeroes, according to the American pharmacopoeia; the number of the zeroes is given by the minimal diameter sufficient to resist to a determined traction and, so, it depends by the material of which the thread is composed.

For example:

- a 4-0 synthetic absorbable or nonresorbable American thread is equivalent to an European thread 1.5 and indicates a thread with the calibre equal to 0.15 mm;
- a 1 natural absorbable American thread coresponds to the 5 European equivalent to a calibre of 0.50 mm;
- a 7-0 natural absorbable American thread corresponds to the 0.7 European equivalent to a calibre of 0.070 mm.

Often the suture threads are coloured with colouring agents approved by the FDA (Food and Drug Administration) to facilitate the visibility in the tissue.

Nonresorbable Sutures

Silk

In the within of the nonresorbable suture threads, the silk (Figures 10-12), a natural, interlaced or skewed multifilament, covered with wax or silicone to reduce the capillarity[2]), deriving from the cocoon of the silk worm and constituted for the 70% by natural proteins and for the 30% by stranger material, is always the more used suture material. Many manufacturers impregnate and cover the thread with waxes and silicones to reduce the capillarity, to increase the impermeability and the fluency.

It offers disadvantages as a tissue reaction, correlated with the bacteria nidation in the filaments interstices, reason for which it is to avoid its employment in the presence of infected wounds, it is insufficiently resistant, few elastic and flowable (Figure 13). Therefore, because of its inflammatory reaction, is not agreable its employment in infected tissues.

Between the advantages we number the good flexibility, a good estate of the knot and manoeu-

Figure 10. Surgical knot of a multifilament suture (silk) on a simulator.

Figure 11. Opening silk suture during an intra-operatory phase in an operation finalized to the rehabilitation of a monoedentulia in the mandibular arch with the positioning of an implant fixture.

vrability and in last, but not for last, the low cost.

Polyamides

The polyamides (Figure 2 and Figures 14-15) are nonresorbable synthetic polymers from which is obtained the fiber named Nylon. They are introduced in commerce with the formulation of monofilament or interlaced and skewed multifilament. The monofilament is endowed with fluency, scarce tissue traumatism and absence of capillarity. The covering of the interlaced multifilament is of silicone; the skewed multifilament is covered with a nylon girdle. In contact with the tissues this fiber endures a partial degradation, by the macrophages, that concurs the *adipic acid* and *esamethylendyamine* liberation, agents that are strong antibacterials. Its rigidity and the memory conserved weaken the knot held ability and render it few manageable.

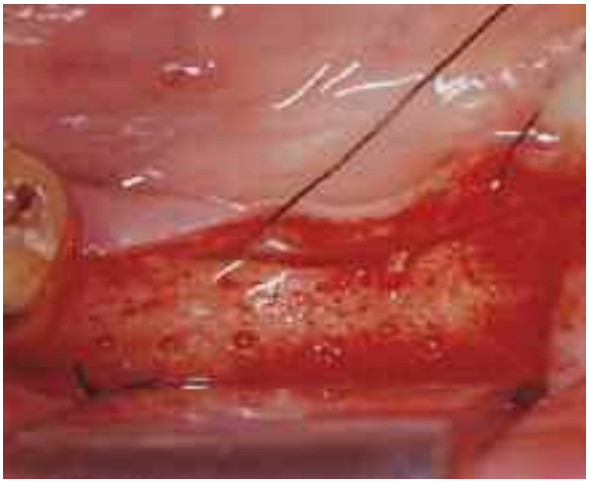

Figure 12. Opening silk suture in an intra-operatory phase consisting in the preparation of the surgical alveoli in an implant operation.

Figure 13. Silk suture that shows its saturation with oral fluids and bacterial plaque.

Polyesters

The polyesters (Figure 9 and Figures 16-20) are nonresorbable synthetic products and can be preparated as monofilaments and interlaced multifilaments, at their time covered or non covered with a girdle. The monofilament is characterized by a scarce accumulation of pathogenic germs

Figure 14. Healing phase at 15 days of a surgical wound sutured with a monofilament (polyamide).

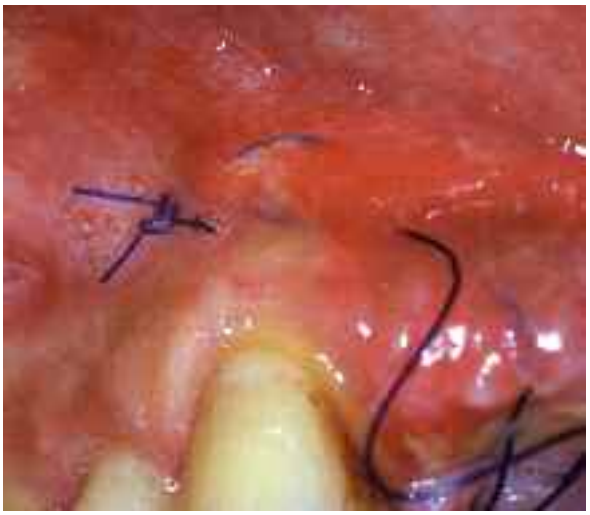

Figure 15. Healing phase at 15 days of a surgical wound sutured with a monofilament (polyamide). Detail.

and it is few traumatic for the tissues.

The non covered multifilament has a rough surface that traumatizes the tissue and favours the germs accumulation. For this reason the multifilaments are preferred coated with the silicone, the teflon, the polyethylene and the vinyl acetate.

Polypropylene

The polypropylene is a nonresorbable synthetic monofilament obtained by the polymerization of the propylene. More elastic, but less resistant than nylon, it presents a good knot fluency and held, does not favourite the germs accumulation, but is less used in oral surgery because of its rigidity, especially for medium-calibre sutures, as the 3/0.

Polyethylene

Belong to this group various types of sutures, as the polytetrafluoroethylene (PTFE), better

Figure 17. Multifilament suture (polyester) afte the insertion of implant fixtures in the mandibular arch: lingual view.

known with the name of GORE-TEX, although its use, nowadays, has gone encounter to a marked lessening, and the polyvinylidene fluoride (PVDF). This last one is a monofilament characterized by a high resistance to the traction, superior than polypropylene, by a great flexibility, a low memory and a minimal tissue reaction, due to a biological and chemical inertia.

These characteristics render the suture more manageable, flowable and with a good knot estate, although medium-calibre filaments, as the 3/0, can create, as many monofilaments, traumatic lesions to the tissues; this trauma decreases with the employment of 5/0 and 6/0 sutures.

Parirokh et al.[3] evaluated and compared the plaque accumulation on polyvinylidene fluoride (PVDF) sutures compared to control groups with silk sutures, maked on male albino rabbits.The sutures were removed after 3.5 and 7 days from their positioning and analyzed by the scanning electron microscope (SEM).

The SEM observation evidenced a minor contamination of the PVDF sutures, compared to the silk sutures.

Leknes et al.[4] evaluated the tissue reactions at silk and expanded polytetrafluoroethylene (e

Figure 16. Multifilament suture (polyester) after the insertion of implant fixtures in the mandibular arch: buccal view.

Figure 18. Multifilament suture (polyester) after the insertion of implant fixtures in the mandibular arch. Detail.

Figure 19. Multifilament suture (polyester) after the insertion of implant fixtures in the mandibular arch. Healing phase at 7 days.

PTFE) sutures in the presence and absence of the anti-infective therapy. They were examined thirty-six sutures 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 the anti-infective therapy including topical 2% chlorhexidine (CHX) solution and a systemic broad-spectrum antibiotic. The Authors concluded that the anti-infective therapy can reduce the biofilm formation and the inflammation along the suture track. Moreover, the silk sutures resulted more susceptible to produce inflammatory reactions than ePTFE sutures.

Absorbable Sutures

Catgut

The catgut is a natural absorbable suture, constituted by a multifilament obtained from the ovine intestine submucosa or from cattle small intestine serosa.

Figure 20. Multifilament suture (polyester) after the insertion of implant fixtures in the mandibular arch. Healing phase at 7 days. Detail of healing.

This material resists unchanged in the tissues for a period of time of approximately 8 days. Later it comes degraded within 30 days by enzymatic digestion mediated by the action of lymphocytes and macrophages. In the oral cavity, with the absorption of the fluids, it endures a volumetric increase of the 40% and a reduction of the 20-30% of the force, that determines often the knot issolution: to avoid this it results obvious the necessity to cut the longer than normal heads of the knot[5]. The catgut is particularly indicated in the suture of deep structures (periosteum, subcutaneous tissue, vessels ligatures) and in the non collaborating subjects. It is contraindicated in the cases of delayed healing of the wounds. Moreover, is to remember its high capillarity. Thanks to the chromium salts addition to the original product is possible to delay the resorption until to the eighteenth day. Today the catgut is re-proposed by many manufacturers, that use raw materials coming from animals breeded in protected and rigorously controlled environments.

Polygalactic Acid

The polygalactic acid is an absorbable synthetic multifilament, constituted for the 90% by glycolic acid and for the 10% by lactic acid. Its resistance is reduced remarkably in the first 20 days to cancel itself completely in the sixtyth day. It is characterized by a calcium stearate coating.

Polydiossanone

The polydiossanone, known with the PDS acronym, is an absorbable synthetic monofilament deriving from the glycolic acid, for substitution of the oxygen atom binded to the second carbon, with two hydrogen atoms. It is characterized by an optimal manoeuvrability, by reduced capillarity and bacterial adhesion, by a traction resistance superior than the polygalactic acid suture. The resorption begins 0-15 days to be completed in 90-180 days.

Polyglycolic acid

The polyglycolic acid or polyglycolide (PGA) is a biodegradable, thermoplastic polymer and is the simplest member of the linear alyphatic polyesters family. It can be sinthetized through condensation or polymerization with the glycolic

acid ring opening. The PGA constitutes interlaced multifilament suture threads and can present itself in a coated and non coated shape. The coating concurs to obtain a pseudo-monofilament structure that reduces the capillarity, increases the sliding, but it facilitates the knot dissolution. It presents a slow resorption that begins after 10-15 days, to be completed in 90-180 days. The degradation process is erosive and seems to follow two passages, during which the polymer comes reconverted to glycolic acid.

First phase: the water insinuate in the non crystalline amorphous regions of the material, separating the ester bindings presented.

Second phase: it begins when the amorphous region has been eroded, leaving exposed to the water action the crystalline portion of the polymer. When the crystalline structure collapses, the polymer chain is dissolved.

When exposed to physiological conditions, the PGA is degraded by processes of casual hydrolysis, but also by some enzyme classes (in particular pertaining to the estherase family). The degradation product, the glycolic acid, is not toxic and can enter in the Krebs cycle, to the end of which is degradated in water and carbon dioxide. A part of the glycolic acid is eliminated with the urine.

Several studies[6] performed on polyglycolic acid sutures showed how the material loses the half of its resistance in approximately two weeks and the 100% in a month. The polymer is then completely absorbed by the organism in a temporal window of 4-6 months.

Currently, the PGA and its co-polymers are widely used as materials for the preparation of absorbable sutures and they are also on the middle of various biomedical studies. The PGA fibres are characterized by an enough elevated traction resistance, approximately 7 Gpa.

To obtain polymers with specific characteristics, various PGA co-polymers were prepared using other monomers. The co-polymers have intermediate characteristics in terms of degradation speed and solubility in dependance of the relationship between the various monomers used in the synthesis and of the same monomer nature.

Between the multiple types of PGA sutures, the SSA 90 is characterized by a polycaprolactone and calcium stearate coating that confers an optimal manoeuvrability, a good fluency to the same suture, also after various passages in the tissues. The SSA 90 is characterized by a very high initial resistance, that happens after approximately 50-80 days after the placement.

Discussion

The sutures used in the oral and maxillofacial surgery must be different from those used by other branches of medicine in various anatomical districts of the human body, because of the type of the tissues involved, the constant presence of saliva, the temperature variations, the high level of vascularization and functions as masticatory, phonetic and respiratory render the oral cavity a unique district. A good suture material must not interfere with the cellular proliferation or with the connective tissue organization.

Banche et al.[7] examined the oral microbial colonization on various suture materials from the oral cavity of patients undergoing dentoalveolar surgery.

The following microorganisms were isolated:

- Aerobic: *Streptococcus spp (Streptococcus mitis, Streptococcus sanguis, Streptococcus oralis, Streptococcus mutans, Gemella morbillorum), Staphylococcus warneri, Neisseria spp, Actinomyces spp, Pasteurella spp.*
- Anaerobic: *Veillonella parvula, Peptostreptococcus spp, Actinobacillus spp, Prevotella spp,* and *Fusobacterium spp.*

A greater quantity of bacteria was found on nonresorbable sutures than on absorbable ones.

In two cases the aerobic pathogen *Pseudomonas aeruginosa* and the yeast *Candida albicans* were isolated.

The suture choice must be made in relation to the type of operation that must be performed. In anatomic regions such as the nasal and oral mucosa that demand higher tensile strength, the multifilament synthetic suture material is prefered. In ares that demand lower tensile strength the monofilament suture material is suggested.

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 surgical wounds healing.

Streptococcus mitis, Streptococcus sanguis and *Streptococcus oralis*, which are well known as colonizers of tooth surface and part of the normal flora, are described as endocarditis pathogens. Recent studies[8] report that systemic disease such as aspiration pneumonia, organ abscess and septicemia associated with cancer chemotherapy or radiothera-

py, 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.

Otten et al.[8] showed that bacteriemia may result from the removal of sutures, that is a potential risk for endocarditis, involving intraoral bacteria such as *Streptococcus sanguis, Streptococcus oralis* and *Streptococcus salivarius*.

The Authors suggest to remove sutures as early as possible (6 to 10 days) after oral surgery operations.

Ulterior considerations found in literature are that inherent the correlation between the use of monofilament or multifilament suture threads and the inflammatory reaction of the intraoral tissues. Lilly et al.[9] observed a reduced inflammatory reaction with the use of monofilament suture material compared with tissues sutured with multifilament suture. These results support Katz and Evans'[10] thesis that the physical characteristics of suture material may be a major determinant of tissue response. Lilly et al.[11] tested the hypothesis that the more severe response to multifilament sutures was caused by bacteria colonizing the interstices of suture by comparing the effect of systemic antibiotics tissue response to monofilament and multifilament sutures.

Homsy et al.[12] reported similar differential tissue response but suggested that the difference was caused by physical features of the suture, such as increased surface area and swelling when hydrated.

Scher et al.[13] found significantly fewer bacteria adhered to the polypropylene monofilament than either of the polyester multifilament sutures.

However, many clinicians prefer the multifilament because the monofilaments are more difficult to manipulate and have sharp ends that irritate the oral tissues.

Grigg et al.[14] evaluated the microbial wicking characteristics in different multifilament suture threads (silk, polyglycolic acid and polygalactic acid) contaminating the experimental environment with *Streptococcus salivarius*. From their results is deduced that all the evaluated multifilament sutures saturate and entertain fluids after 48 h, but the polyglycolic acid does it more rapidly.

Conclusions

In this study were re-examinated the characteristics and the properties of the suture threads mainly used in oral surgery, based on their nature and chemical composition. The healing modalities of the surgical wounds and the suture threads interaction with the biological tissues with which they come in contact, were described.

Evaluating the results of the different studies present in literature, the Authors conclude that the suture threads would be used in relation to the type of surgical operation that the clinicians mean to perform, after estimating the patient compliance, because an ideal suture thread doesn't exist.

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