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BACTERIAL ACCUMULATION ON DIFFERENT TYPES OF SUTURING MATERIALS IN PERIODONTAL SURGERY AND IMPLANTOLOGY - LITERATURE REVIEW

БАКТЕРИСКА АКУМУЛАЦИЈА НА РАЗЛИЧНИ ВИДОВИ НА МАТЕРИЈАЛИ ЗА СУТУРИРАЊЕ ВО ПАРОДОНТАЛНАТА ХИРУРГИЈА И ИМПЛАНТОЛОГИЈА – ПРЕГЛЕД НА ЛИТЕРАТУРА

Mitikj J.[1], Georgieva S.[2], Shushak Z.[3], Mitikj K.[2]

[1]PHI „Guda Dent“ Skopje, Republic of North Macedonia, [2]“Ss. Cyril and Methodius” University in Skopje, Faculty of Dentistry – Skopje, Republic of North Macedonia, [3]PHI “Dentoria-1 - Specialist practice for oral surgery and implantology” Ohrid, Republic of North Macedonia

Abstract

Suturing materials are artificial products used for intimate approximation of the wound margins, until they are capable of self-healing with the help of natural collagen fibers. The ideal suture material must have the following characteristics: strength, knot stability, flexibility, easy handling, minimal tissue response and resistance to infection. There is a wide range of suturing materials and they are used in both periodontal surgery and implantology. Today, the number of alternative products that are used as sutures has increased, as well as synthetically produced products. We mainly classify suturing materials as nonresorbable and resorbable. Furthermore, they can be subclassified as natural and synthetic as well as monofilament or multifilament materials. In this review paper we performed an electronic database search and tracked the inflammatory reactions of tissues when using different types of suturing materials. In the paper we have highlighted the more significant trends in new types of sutures. Tissue reactions vary depending on the surface of the materials and the bacterial adhesion to them. **Key words:** suturing materials, inflammation, bacterial accumulation, periodontal surgery, implantology.

Апстракт

Материјалите за сутурирање се артифициелни производи кои се користат со цел интимно прилепување на рабовите на раната, се додека истите не бидат оспособени за самостојно зараснување со помош на природните колагени влакна. Идеалниот материјал за сутура мора да ги поседува следните карактеристики: цврстина, стабилност на јазолот, флексибилност, лесна манипулација, минимална ткивна реакција и резистентност кон инфекциите. Постои широк спектар на материјали за сутурирање и истите се употребуваат како во пародонталната хирургија, така и во имплантологијата. Зголемен е бројот на алтернативните продукти кои денес се користат како сутури, а исто така и на синтетички произведените продукти. Главно, материјалите за сутурурање ги класифицираме како нересорптивни и ресорптивни. Понатаму, можат да бидат супкласифицирани на природни и синтетички, како и на монофиламентни или мултифиламентни материјали. Во овој ревијален труд извршивме електронско пребарување на базите на податоци и ги проследивме инфламаторните реакции на ткивата при користењето на различни типови на материјали за сутурирање. Во трудот ги нагласивме позначајните трендови кај новите типови на сутури. Реакциите на ткивата се разликуваат во зависност од површината на материјалите и бактериската атхезија кон истите. **Клучни зборови:** материјали за сутурирање, инфламација, бактериска акумулација, пародонтална хирургија, имплантологија.

Introduction

Suturing is the final part of a surgical intervention, used for closure of wound margins, bleeding control, and aims towards a primary wound healing[1]. The suture material is an artificial product used for intimate approximation of wound margins until they can hold sufficiently well by themselves by natural collagen fibers[2].

The first description of suture materials dates back to 3000 years BC, from ancient egyptian literature[3]. The suture materials used in that period included hemp, linen, fiber, grass, reed, and metal wires[4]. Many famous surgeons

such as Sushruta, Galen and Antyllus have described suturing techniques using primitive materials[5]. For centuries, the material of choice was catgut[6]. In the 1800s, Joseph Lister introduced the technique of sterilizing catgut, while in 1906 this technique has been finally perfected[7]. In the early 20th century, synthetic suturing materials were developed such as polyglycolic acid, polyglactin, and polypropylene[8].

The ideal suture material should have great strength, knot stability, flexibility, should be easy to manipulate, should cause minimal tissue reaction and be resistant to infections[9]. Commercially available materials are classified according to different criteria: three-dimensional structure (monofilament, multifilament), tissue stability (resorbable, non-resorbable) and origin of the material (natural, synthetic)[10]. Suturing materials are potential risk factors for wound infection obtained during periodontal surgery, and their success depends on the primary wound healing and the absence of bacteria at the healing site[11,12]. The bacterial accumulation is greater in the oral environment than in other tissue areas, due to differences in the quality of the tissues that are involved, the presence of the saliva, the high vascularity, the functions and the parafunctions[13]. The suture surface provides a conductive environment for growth of microorganisms on surgical sites[14]. The multifilament and the resorbable suturing materials produce a greater inflammatory response[15]. The monofilament materials reduce the number of bacteria, but are difficult to handle, and the patient's discomfort is increased[16].

The studies conducted by Varma et al., Elek and Cohen, Raju et al. specify that a certain number of microorganisms is necessary to cause infection in a clean surgical wound[17]. Kathju et al. in their papers suggest that contamination of sutures with biofilm during implantation requires eventual removal of the infected material[18,19]. It is recommended to monitor the wound healing for early identification of signs and symptoms associated with surgical complications[20]. Landry, Turnbull and Howley[21,22] proposed an index to determine the degree of recovery following a periodontal surgery. Bacterial plaque samples are taken from the sutures using a swab test and are cultured for further microbiological analysis[23]. Suture materials act as a risk factor for infections due to their ability to adhere pathogenic bacteria on the surface and are the focus of infections[24]. Reduction of postoperative bacterial accumulation is a very important segment in regenerative periodontal surgery in order to prevent soft tissue dehiscence and exfoliation of the membrane[25]. In mucogingival surgery, increased bacterial accumulation leads to postoperative gingival recession and aesthetically unacceptable results. The authors recommend using a minimum number of sutures to close the flap, as sutures and knots cause inflammation, and delay the healing of the wound[26].

In our paper we performed a search of available literature data using the following databases: PubMed/MEDLINE, Embase and Cohrane Library. The search was conducted electronically, and we used studies published in English. This review is conducted in accordance with the preferred reporting items for systematic reviews and the declaration standards for meta-analyzes (PRISMA) for systematic reviews.

Discussion

This review paper provides an overview of the most commonly used suture materials in both periodontal surgery and implantology, as well as differences in the bacterial accumulation of appropriate materials. 73 studies of a heterogeneous nature were included in the paper. Numerous suturing materials are available to be used during surgical interventions, but it is essential for periodontists to be aware of the nature of the material, the biological healing process and the interaction of the suturing material with the surrounding tissues.

NON-RESORBABLE SUTURING MATERIALS

Suturing materials that cannot be damaged by living tissues are called non-resorbable and are most commonly used in percutaneous wound closures.

Natural

Silk

The use of silk as a suture material began in 1890. It is a product of the larvae of silkworms[27]. Silk is a non-resorbable, natural, multifilament material that is preferred by many surgeons due to its easy handling, good strength and stability[28]. Wax or silicone coating help reduce friction and capillarity. It is classified as non-resorbable material because a complete degradation occurs after 2 years. They are widely accepted in the closure of mucosal wounds and ligation of blood vessels, because they are affordable[29,30]. Due to their multifilament nature, many species of microorganisms adhere to the suture material and cause inflammation[31]. The research of Selvig et al.[32] between silk and chromed catgut, have shown that bacterial invasion of sutures is a common outcome, but it is more pronounced in silk. However, silk has been the most commonly used natural suture material in the last 100 years[33]. Yaltiriki et al. studied the colonization of various microorganisms over natural materials and noticed that it was more significant in silk[34]. According to the researches by Vishaka et al., the use of silk will increase in the future as the trend changes from synthetic to natural threads to reduce environmen-

tal impacts. Besides that, the material is on its way to bioengineering[35].

Synthetic

Nylon (Polyamide)

Nylon is the first synthetic suturing material produced in 1940. It is available in monofilament and multifilament form and it is composed of long chains of aliphatic polymers of nylon 6[36]. It is characterized by minimal induction of cellular response and prolonged suture stiffness retention[37]. Nylon is extremely inert but elastic and has a biodegradation rate of 20% per year[38]. It is found as a monofilament and multifilament material, and the main disadvantage is the poor reliability of the knot and being more difficult to be manipulated. Several studies have shown that nylon suture gives the best biological results and the least inflammatory response[39,40,41]. Castelli et al. compared the tissue inflammatory response between silk, cotton, and nylon, and the results showed that nylon did not elicit any form of inflammatory response in oral tissues compared to other materials[41].

Polypropylene (Prolene)

Polypropylene was introduced as a suturing material in 1962[42]. It is a synthetic material available in monofilament form that causes a limited allergic reaction and does not adhere to tissues. However, it often results in formation of fistulas, pain, and palpable nodules, and the wound infection rate can be up to 24%[43,44]. The friction strength is higher than in other materials[42]. The manipulation of the material is easy and the knot is stable[45]. In their study, Selvi et al. examined the difference in healing between 4 suture materials, including silk, polypropylene, coated polyglactin 910, and polyglecaprone 25. They concluded that polypropylene was causing a significantly smaller inflammatory reaction in the tissues[46].

RESORBABLE SUTURING MATERIALS

Suturing materials are categorized as resorbable when they lose their hardness 60 days after suturing.

Natural

Catgut

These materials are derived from purified connective tissue (predominantly collagen) from the small intestine of sheep or cattle[47]. It is a monofilament material, absorbed through the mechanism of enzymatic digestion which leads to greater inflammation[48]. It is available in two forms: plain and chromed. Plain catgut is resorbed in 7 days, and the chromed one in a period of 20 to 40 days[49,50]. When catgut is used as a suture material, the risk of infection increases, due to which it has been banned in EU countries and Japan[51]. It is difficult to manipulate with poor knot stability when wet[52]. Clinical studies point to catgut as a material with a higher inflammatory response compared to other materials[53,34]. But Selvig et al.[54] in their study prove that bacterial invasion is greater in silk than in catgut. The results of a study by Fomete et al.[55] show that catgut is resorbed faster than indicated on the package due to enzymes and pH variations in the oral environment.

The use of catgut was highest in the 19th century. In 1868, Joseph Lister was the first to use a catgut coated with an antibacterial agent. Over time, the use of catgut became less popular due to the emergence of more modern synthetic resorbable materials on the market[56].

Synthetic

Polyglycolic acid (Dexon)

The first resorbable suturing materials were manufactured in the United States in 1962, and Dexon was introduced to the market in the late 1960s[57]. Polyglycolic acid (PGA) is a polymer of glycolic acid and it is a synthetic, resorbable, multifilament material[58]. PGA sutures have excellent strength and reduced tissue response. The resorption takes place through the mechanism of biodegradation[59]. On the seventh day it retains 60% of the firmness, 35% on the 14th day, and 5% on the 28th day. A complete resorption occurs within a period from 60 to 90 days. One clinical study showed that PGA sutures showed greater inflammation of the wounds than resorbable monofilament materials[60]. Lilli et al.[61] compared resorbable PGA materials with silk and catgut. The bacterial accumulation was higher in silk and PGA due to their multifilament nature. Modern resorbable synthetic sutures have the opposite effect, and researchers suggest that suture degradation products create an antimicrobial environment that stops the bacterial growth and transport[62].

Polyglactin 910 (Vicril)

Polyglactin 910 (Vicryl) consists of a copolymer of 90% glycolide and 10% l-lactide[63]. It is a resorbable, multifilament synthetic material, and its resorption occurs by hydrolysis[64]. It shows complete resorption between 56 and 70 days and loses 50% of its firmness after 3 weeks[65]. Vicryl Rapide is completely resorbed

after 42 days and loses strength after 14 days[66]. Gamma radiation alters the molecular structure of polyglactin 910 and increases the rate of resorption. Several studies have shown reduced bacterial adhesion to the suture material and improved wound healing with the use of Vicryl Plus antibacterial sutures (polyglactin 910 coated with triclosan)[67,68,69]. In their study, Storch et al.[70] did not show a significant difference in wound healing between the use of Vicryl and Vicryl Plus materials.

Poliglecaprone 25 (Monocryl)

Poliglecaprone 25 (monocryl) was introduced to the market in 1993. 20-30% of the firmness is retained 14 days after suturing, and complete hydrolysis occurs after 90 to 120 days[71]. In a study by Yilmaz et al.[72], proliglecaprone 25 showed positive effects in wound healing compared to other materials. An antibacterial form (Monocryl plus) is also available. Sala-Pérez et al, in their clinical study showed the antibacterial effect of Monocryl Plus sutures on the third day, but this effect was negligible 7 days after surgery[73].

Conclusion

The suturing materials used in periodontal surgery and implantology, despite the advances in science and technology, do not possess all the necessary features that lead to primary wound healing and good postoperative results. Despite the fact that the non-resorbable material "silk" shows poor results in clinical and paraclinical parameters, it still remains the most commonly used suturing material. Materials such as Nylon and Polypropylene are slowly but surely gaining ground for their use as non-resorbable materials, only their high price is a partial barrier to wider application. Catgut material is definitely out of use in periodontal surgical intervention, and in the resorptive range of suturing materials, Vicryl, Monocryl and Polyglycolic acid are the materials of choice that give solid and satisfactory results.

Reference

1. Sekhar A, Abdul Basheer S, NAIR A. (Microbiological evaluation of bacterial plaquein suture material used post-extraction. JCR. 2020; 7(19): 10164-10173.
2. Hassan H K. Dental Suturing Materials and Techniques. Glob J Oto 2017; 12(2): 555833.
3. Kavin T, etal. "Suturing Vs Non-Suturing Techniques in Oral Surgery –A Review ofLiterature". IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), 19(2), 2020, pp. 10-13.
4. Rose J, Tuma F. Sutures And Needles. [Updated 2020 Sep 5]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.
5. Pillai CK, Sharma CP. Review paper: absorbable polymeric surgical sutures: chemistry, production, properties, biodegradability, and performance. J Biomater Appl. 2010 Nov;25(4):291-366.
6. D Mackenzie. The history of sutures. Med Hist 1973 Apr;17(2):158-168.
7. Worboys, Michael. (2013). JOseph Lister and the performance of antiseptic surgery. Notes and records of the Royal Society of London. 67. 199-209.10.1098/rsnr.2013.0028.
8. Schiappa, Jose & Van Hee, Robrecht. (2012). From Ants to Staples: History and Ideas Concerning Suturing Techniques. Acta chirurgica Belgica. 112. 395-402.
9. Açan, Ahmet & Hapa, Onur & Barber, F.. (2018). Mechanical Properties of Suture Materials. 10.1007/978-3-662-56108-9_3.
10. Etemadi A, Bitaraf T, Amini A, Goudarzi M, Nadafpour N. Bacterial Accumulation on TriclosanCoated and Silk Sutures After Dental Implant Surgery. J Res Dentomaxillofac Sci. 2019;4(3) :1-4
11. Asher R, Chacartchi T, Tandlich M, Shapira L, Polak D. Microbial accumulation on different suture materials following oral surgery: a randomized controlled study. Clin Oral Investig. 2019 Feb;23(2):559-65.
12. Karde PA, Sethi KS, Mahale SA, Mamajiwala AS, Kale AM, Joshi CP. Comparative evaluation of two antibacterial-coated resorbable sutures versus noncoated resorbable sutures in periodontal flap surgery: A clinico-microbiological study. J Indian Soc Periodontol 2019;23:220-5.
13. Banche G, Roana J, Mandras N, Amasio M, Gallesio C, Allizond V, et al. Microbial adherence on various intraoral suture materials in patients undergoing dental surgery. J Oral Maxillofac Surg 2007;65:1503–1507.
14. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for disease control and prevention (CDC) hospital infection control practices advisory committee. Am J Infect Control 1999;27:97?132.
15. Minozzi F, Bollero P, Unfer V, Dolci A, Galli M. The sutures in dentistry. Eur Rev Med Pharmacol Sci. 2009 May-Jun;13(3):217-26.
16. Pons-Vicente O, López-Jiménez L, SánchezGarcés MA, Sala-Pérez S, Gay-Escoda C. A comparative study between two different suture materials in oral implantology. Clin Oral Implants Res. 2011 Mar;22(3):282-8.
17. Mahesh, L., Kumar, V. R., Jain, A., Shukla, S., Aragoneses, J. M., Martínez González, J. M., Fernández-Domínguez, M., & Calvo-Guirado, J. L. (2019). Bacterial Adherence Around Sutures of Different Material at Grafted Site: A Microbiological Analysis. Materials (Basel, Switzerland), 12(18), 2848.
18. Kathju, S.; Nistico, L.; Hall-Stoodley, L.; Post, J.C.; Ehrlich, G.D.; Stoodley, P. Chronic surgical site infection due to suture - associated polymicrobial biofilm. Surg. Infect. 2009, 10, 457–461.
19. Kathju, S.; Lask, L.A.; Nistico, L.; Colella, J.J.; Stoodley, P. Cutaneous fistula from gastric remnant resulting from chronic suture-associated biofilm infection. Obes. Surg. 2010, 20, 251–256.
20. PippiR. Post-Surgical Clinical Monitoring of Soft Tissue Wound Healing in Periodontal and Implant Surgery.Int. J. Med. Sci.2017; 14(8): 721-728.
21. Landry RG, Turnbull RS, Howley T. Effectiveness of benzydamyne HCl in the treatment of periodontal post-surgical patients. Res 1988;10:105-118.
22. Masse JF, Landry RG, Rochette C, et al. Effectiveness of soft laser treatment in periodontal surgery. Int Dent J 1993;43:121-127.
23. Shah M A, Shah B K, Dave D H, Shah S S. Comparative evaluation of microbial colony counts on sutures with and without use of periodontal pack: a split mouth, randomized controlled study. J Integr Health Sci 2013;1:90-4.

24. Singh, P. K., Narayan, S. J., Narayan, T., Yadalam, U., Raghava, V., & Singh, I. (2020). Microbial Adherence of three different suture materials in patients undergoing periodontal flap surgery. A clinical & microbiological study. UNIVERSITY JOURNAL OF DENTAL SCIENCES, 6(2): 282.
25. Selvig KA, Kersten BG, Chamberlain AD, Wikesjo UM, Nilveus RE. Regenerative surgery of intrabony periodontal defects using ePTFE barrier membranes: Scanning electron microscopic evaluation of retrieved membranes versus clinical healing. J Periodontol 1992;63:974978.
26. Velvart P, Peters CI. Soft tissue management in endodontic surgery. J Endod 2005;31:4 –16.
27. Silverstein LH, Kurtzman GM. A review of dental suturing for optimal soft -tissue management. Compend Contin Educat Dent (Jamesburg, NJ: 1995) 2005;26(3):163–166.
28. Baqain ZH, Moqbel WY, Sawair FA. Early dental implant failure: Risk factors. Br J Oral Maxillofac Surg 2012;50(3):239-243.
29. Jo YY, Kweon H, Kim DW, et al. Accelerated biodegradation of silk sutures through matrix metalloproteinase activation by incorporating 4-hexylresorcinol. Sci Rep. 2017;7:42441.
30. Gogoi D. et al.. Development of advanced antimicrobial and sterilized plasma polypropylene grafted muga (antheraea assama) silk as suture biomaterial. Biopolymers 101, 355–365 (2014).
31. Chen X, Hou D, Tang X, Wang L. J Mech Behav Biomed Mater. 2015 Oct; 50():160-70.
32. Selvig KA, Biagiotti GR, Leknes KN, et al. Oral tissue reactions to suture materials. Int J Periodont Res Dent 1998;18: 475-487.
33. Thilagavathi, G. and S. Viju. "Silk as a suture material." (2015).Advances in silk science and technology, 219-232.
34. Yaltirik M, Dedeoglu K, Bilgic B, Koray M, Ersev H, Issever H, et al. 2003. Comparison of four different suture materials in soft tissues of rats. Oral Dis., 9:284-286
35. G V, Vishaka & Rathore, Mahender & Muniyappa, Chandrashekharaiah & Nadaf, Hasansab & Sinha, R. (2019). Studies on Silk as a suture in medical science.
36. Kudur MH, Pai SB, Sripathi H, Prabhu S. Sutures and suturing techniques in skin closure. Indian J DermatolVenereol Leprol 2009;75:425-34.
37. Jamali H, Abuali M, Khalili MR. Clinical Outcomes of Silk versus Nylon Sutures for Suturing of Conjunctival Autograft in Pterygium Surgery. Middle East Afr J Ophthalmol. 2020;27(2):110-116.
38. Goel A. Surgical Sutures - A Review. Delhi JOphthalmol 2016;26:159-62.
39. R. S. Abi Rached, B. E. de Toledo, T. Okamoto et al., "Reactionof the human gingival tissue to different suture materials usedin periodontal surgery," Brazilian Dental Journal, vol. 2, no. 2,pp. 103–113, 1992.
40. Javed F, Al-Askar M, Almas K, Romanos GE, Al-Hezaimi K. Tissue reactions to various suture materials used in oral surgical interventions. ISRN Dent.
41. W. A. Castelli, C. F. Nasjleti, R. Diaz-Perez, and R. G. Caffesse, "Cheek mucosa response to silk, cotton, and nylon suture materials," Oral Surgery Oral Medicine and Oral Pathology, vol. 45, no. 2, pp. 186–189, 1978.
42. Gowtham K, Anandh B, Srinivasan K, Umar M. Suture Materials in Dental Surgeries: A Review. Ann SBV 2020;9(1): 30–32.
43. Aldhabaan S, Hudise J Y, Alqarny M, et al. (August 15, 2020) Catgut Versus Polypropylene Sutures for Transcolumellar Incision Closure in Open Rhinoplasty: A Retrospective Cohort Study.
44. Kiran Shankar H: A comparative study of outcome of the absorbable suture polydioxanone and non-absorbable suture polypropylene in laparotomy wound closure. Int J Res Med Sci. 2016, 4:2084-2088.
45. Seki M, Yamamoto S, Abe H, Fukuchi T. Modified ab externo method for introducing 2 polypropylene loops for scleral suture fixation of intraocular lenses. J Cataract Refract Surg 2013; 39:1291-6.
46. Selvi F, Cakarer S, Can T, et al. Effects of different suture materials on tissue healing. J IstanbUnivFac Dent. 2016;50(1):35-42.
47. Kudur MH, Pai SB, Sripathi H, Prabhu S. Sutures and suturing techniques in skin closure. Indian J DermatolVenereolLeprol 2009;75:425-34.
48. MacLean AB, MacLean SB. Suture materials and subsequent wound strength. J ObstetGynaecol. 2008;28(6):561-562.
49. Dennis C, Sethu S, Nayak S, Mohan L, Morsi Y, Manivasagam G. Suture materials—current and emerging trends. J Biomed Mater Res A 2016;104(6):1544–1559.
50. Sharma, Pramod. (2019). Superiority of absorbable synthetic sutures over catgut suture in obstretic and gynaecology sugeries: evidence based review.
51. Saraí C. Guadarrama-Reyes, Rogelio J. Scougall-Vilchis, Raúl A. Morales-Luckie, Víctor Sánchez-Mendieta and Rafael López-Castañares (March 15th 2018). Antimicrobial Effect of Silk and Catgut Suture Threads Coated with Biogenic Silver Nanoparticles, Silver Nanoparticles - Fabrication, Characterization and Applications, Khan Maaz, IntechOpen.
52. Tan, Rachel & BELL, RJW & DOWLING, BA & Dart, Andrew. (2003). Suture materials: composition and applications in vetern-ary wound repair. Australian Veterinary Journal. 81. 140 - 145. 10.1111/j.1751-0813.2003.tb11075.x.
53. Gazivoda D, et al. A clinical study on the influence of suturing material on oral woundhealing. Vojnosanit Pregl 2015; 72(9): 765–769.
54. Selvig KA, Biagiotti GR, Leknes KN, et al. Oral tissue reactions to suture materials. Int J Periodont Res Dent 1998;18: 475-487.
55. Fomete, Benjamin &Saheeb, Birch &Obiadazie, Athanasius. (2013). A prospective clinical evaluation of the longevity of resorbable sutures in oral surgical procedures. Nigerian journal of clinical practice. 16. 334-8. 10.4103/1119-3077.113457.
56. Gierek M, Kuśnierz K, Lampe P, Ochała G, Kurek J, Hekner B, Merkel K, Majewski J. Absorbable sutures in general surgery - review, available materials, and optimum choices. Pol PrzeglChir. 2018 Apr 30;90(2):34-37.
57. Mackenzie D . The History of Sutures. Med Hist 1973; 17: 158–168.
58. Khiste SV, Ranganath V, Nichani AS. Evaluation of tensile strength of surgical synthetic absorbable suture materials: an in vitro study. J Periodontal Implant Sci. 2013 Jun;43(3):130-5.
59. Moser JB, Lautenschlager EP, Horbal BJ. Mechanical properties of polyglycolic acid sutures in oral surgery. J Dent Res 1974;53:804-8.
60. Chunder A, Devjee J, Khedun SM, Moodley J, Esterhuizen T. A randomised controlled trial on suture materials for skin closure at caesarean section: Do wound infection rates differ? S Afr Med J. 2012;102(6 Pt2):374-376.
61. Lilly GE, Osbon DB, Hutchinson RA, HelfichRH.Clinical and bacteriological aspects of polyglycolicacid sutures. J Oral Surg1973;31:103–105.
62. Geiger, Dieter & Debus, Eike-Sebastian & Ziegler, Ulrich &Larena-Avellaneda, Axel & Frosch, Matthias &Thiede, Arnulf & Dietz, Ulrich. (2005). Capillary Activity of Surgical Sutures and Suture- Dependent Bacterial Transport: A Qualitative Study. Surgical infections. 6. 377-83. 10.1089/sur.2005.6.377.
63. Dixit, Asha & Nadkarni, Purnima & Shah, Viral & Patel, Bhavi&Turiya, Prakash & Thakkar, Ashokkumar. (2018). Evaluation of safety and efficacy of polyglactin 910 suture in surgical incision closure: clinical study protocol for a randomized controlled trial. International Journal of Clinical Trials. 5. 80. 10.18203/2349-3259.ijct20180135.
64. Valle LFC, Mar?ns EA, d'Acampora AJ, Kestering DM, Sakae TM, Russi RF. Estudoda força de ruptura do planomúsculo-

aponeuróco da parede abdominal apóssuturaempontosseparadoscomparandotrêspos deoscirúrgicoemratos Wistar. ACM ArqCatarin Med. 2007;36(1):51-8.
65. Biondo-Simões, Maria & Oda, Marian & Pasqual, Suzane& Robes, Rogério. (2018). Comparative study of polyglactin 910 and simple catgut in the formation of intraperitoneal adhesions. Acta CirurgicaBrasileira. 33. 102-109. 10.1590/s0102-865020180020000001.
66. Odijk, R., Hennipman, B., Rousian, M. et al. The MOVE-trial: Monocryl® vs. VicrylRapide™ for skin repair in mediolateral episiotomies: a randomized controlled trial. BMC Pregnancy Childbirth 17, 355 (2017).
67. Kruthi N, Rajasekhar G, Anuradha B, Krishna Prasad L (2014) Polyglactin 910 vs. Triclosan Coated Polyglactin 910 In Oral Surgery: AComparative In Vivo Study. Dentistry 4: 267.
68. Edmiston CE, Seabrook GR, Goheen MP, Krepel CJ, Johnson CP, Lewis BD, Brown KR, Towne JB. Bacterial adherence to surgical sutures: can antibacterial-coated sutures reduce the risk of microbial contamination? J Am Coll Surg. 2006 Oct;203(4):481-9.
69. Gomez Alonso A, Garcia-Criado FJ, Parreno- Manchado FC, Garcia-Sanchez JE, Garcia-Sanchez E, et al. (2007) Study of the efficacy of coated Vicryl plus antibacterial suture (coated polyglactin 910 suture with triclosan) in two animal models of general surgery. J Infect 54: 82-8.
70. Storch M, Perry LC, Davidson JM, Ward JJ. A 28-day study of the effect of Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 suture with triclosan) on wound healing in guinea pig linear incisional skin wounds. Surg Infect (Larchmt). 2002;3 Suppl1:S89-98.
71. Okamoto T, Rosini KS, Miyahara GI, Gabrielli MF. Healing process of the gingival mucosa and dental alveolus following tooth extraction and suture with polyglycolic acid and polyglactin 910 threads. comparative histomorphologic study in rats. Braz Dent J 1994(1):35– 43.
72. Yilmaz N, Inal S, Muglali M, Guvenc¸ T, Bas¸ B. 2010. Effects of polyglecaprone 25, silk and catgut suture materials on oral mucosa wound healing in diabetic rats: an evaluation of nitric oxide dynamics. Med. Oral, PatologiaOral y CirugiaBucal., 15:e526–e530.
73. Sala-Pérez S, López-Ramírez M, Quinteros-Borgarello M, Valmaseda-Castellón E, Gay-Escoda C. Antibacterial suture vs silk for the surgical removal of impacted lower third molars. A randomized clinical study. Med Oral Patol Oral Cir Bucal. 2016 Jan 1;21(1):e95-102.