INFLUENCE OF DIFFERENT TYPES OF SURGICAL SUTURE MATERIAL ON THE INTENSITY OF TISSUE REACTION IN ORAL CAVITY

ABSTRACT: Throughout the history the most diverse suture material have been used for closing and suturing surgical wounds. The four basic features of suture material are described: knot safety, stretch capacity, tissue reactivity and wound safety. Tissue reaction, even the minimum one, which develops during the first to seven days after applying the suture in the tissue.

The aim of this study was to investigate influence of a monofilament suture material (nylon) on the intensity of local tissue reaction in experimental conditions, and to compare it with the multifilament suture used in the routine practice of oral surgery (silk).

This investigation is a prospective experimental study carried out on Wistar rats. The experiment included 30 animals, in which Black Silk (thickness 4-1) and Nylon (thickness 4-0) were applied in the upper and lower jaw, respectively.

To monitor tissue reaction on different suture materials the following parameters were used: coagulum formation, presence of polymorphonuclear leukocytes, presence of macrophages and granuloma, formation of epithelial bridge and connective tissue, collagen synthesis, granulomatous tissue formation and presence of fibrous tissue.

After comparing parameters for the intensity of tissue reaction to the investigate suture materials by suturing the oral mucosa, certain advantage could be given to the monofilament suture materials.

KEY WORDS: suture material, tissue reaction, oral cavity

INTRODUCTION

Surgery is as old as the mankind, and use of sutures dates back to the times of earliest human knowledge in the field of surgery (6, 7, 8).

Throughout the history the most diverse suture material have been used for closing and suturing surgical wounds. The most ancient suture materials include animal tendons and hairs, as well as herbal fibers such as linen, hemp, and different grass species. Some Egyptian papers, dating back some 5000
years ago, display scenes of suturing wounds with linen fibers. A famous Roman medicus, Galen, introduced sutures made of animal intestines into the surgery (6, 7, 8).

Since Renaissance times until 1940 there were substantial changes with respect to the kind of suture materials used, which involved catgut, cotton and surgical silk. The first synthetic suture materials were nylon and polyester, produced in the 1940’s. Soon afterwards polyethylene and polypropylene were developed. In 1970 the polyglycolic acid was “put on stage,” which is known under the licensed name DEXON (Davies+Geck inc., Great Britain). During 197, the polyglactine 910, which is an essential component of the VICRYL-a (Ethicon Inc., Great Britain), was put on market (6, 7, 8).

The four basic features of suture material are knot safety, stretch capacity, tissue reactivity and wound safety. Knot safety implies capacity of suture material to retain the strength and firmness of the knot, without slackening in the unit of time. It is reverse-proportional to a suture thickness, and directly proportional to its quality and functional output. Stretch capacity of the suture material is defined as a stretch power capacity per unit of area. The wound safety is directly related with suture capacity that is required for safe healing of the wound. Tissue reaction is reflected through an inflammatory reaction, even the minimum one, which develops during the first two to seven days after stitch application into the tissue (6, 7, 8).

The wound healing process encompasses three basic stages — the inflammatory, fibroblastic and remodeling ones. The inflammatory phase begins at the moment of injury, and lasts 3—5 days provided that there is no prolonged inflammation. The main characteristic of the wound in this phase is formation of fibrins of decreased firmness. During the stadium of fibroblastic phase, the fibrin bands permeate the wound building a frame, on which fibroblasts accumulate the ground substance and tropocollagen. Despite poor collagen synthesis, the firmness of the wound increases rapidly during the fibroblastic stadium, lasting 2—3 weeks. At the end of this phase, the wound becomes tight — because of excess collagen, erythematous — because of high degree of vascularization and capable to withstand 70%—80% of the tension of a healthy tissue. During the remodeling phase, substantial amounts of randomly deposited collagen fibers are eliminated and replaced by new fibrils, arranged in a pattern that enables higher firmness of the wound. In this stadium the firmness of the wound increases, yet not exceeding the rate of 80—85% of the firmness of a healthy tissue. (6, 7, 8).

THE AIM

The aim of this study was to investigate influence of a monofilament suture material (nylon) on the intensity of local tissue reaction in experimental conditions, and to compare it with the multifilament suture used in the routine practices of oral surgery (silk).
MATERIAL AND METHODS

The investigation was performed on 30 Wistar rats, aged 3—6 months and with body mass ranging 250—350 g. All experimental animals were distributed into the 3 groups of 10 animals each, according to the time of sampling during the postoperative period (day 2, day 5, and day 7).

On a day of surgery, each animal was anesthetized with 10% urethane (1 ml per 100 gr. body mass). The research design implied making two mucoperiosteal flaps in the anterior segment, i.e. on the right side in the upper jaw and on the left side in the lower jaw. A mucoperiosteal flap was produced by horizontal incision in the attached gingiva, and two vertical relaxation incisions. Horizontal incision was placed 5 mm from the gingival margin. Flap mobilization was performed using Freer raspatorium. Each animal undergone cortex trepanation in the line with the tooth root, interradicularly. Cortex trepanation was performed using round steel borer, 3 mm in diameter, with abundant douching of the drill and working area with sterile physiological saline. Each flap was ecarted for 15 minutes, and then returned to its original location and sutured.

The following suture materials were used: (1) monofilament synthetic material (Nylon®), thickness 4/0, needle with thread, round bodied, curvature 3/8 circle “DR 25”; (2) polyfilament natural silk material (Black Silk®), thickness 4/0, round bodied needle with thread, curvature 3/8 circle “DR 25” (non-traumatic).

In each animal both types of sutures were used, i.e. monofilament in one jaw and polyfilament in another jaw. Each mucoperiosteal flap was sutured with four stitches (with fourfold knot), two in the horizontal, and one in each vertical incision. After suturing, a gauze tampon was placed onto the wound, followed by a digital compression in order to induce hemostasis and to prevent development of hematoma.

The second procedure (Days 2, 5 or 7 upon first surgery, depending on the experimental group), performed in general anesthesia with 10% urethane, encompassed excision of mucoperiosteal portion from the surgery region along with the suture material. The obtained preparations were fixed in 70% alcohol and subjected to histopathological analysis.

To monitor tissue reaction to suture materials the following parameters were used: coagulum formation, presence of polymorphonuclear leukocytes, presence of macrophages and granuloma, formation of epithelial bridge and connective tissue, and presence of fibrous tissue.

Statistical analysis of the obtained results was performed by scaling non-parametric data using Lancaster contingency tables, multivariate and univariate analysis, (MANOVA and ANOVA), and Student’s t-test in proportions.

RESULTS

On a day 2 post-surgery presence of coagulum, i.e. fibrous clot, was observed in all animals from the experimental and the control groups (Table 1).
Identical results were recorded in both groups with respect to the presence of polymorphonuclear leukocytes (in all suture types), presence of granuloma (no evidence of granuloma in neither of the investigated groups), as well as epithelial bridge formation, collagen synthesis and presence of fibrous tissue (observed in neither of the investigated groups). As regard to the presence of macrophages in the wound, they were not observed only in two animals from the experimental group, whereas they were detected in all remaining animals on a day 2 post-surgery.

Tab. 1 — Prevalence of tissue reaction parameters on day 2 post-surgery

<table>
<thead>
<tr>
<th>Group</th>
<th>Tissue reaction rate*</th>
<th>Koag</th>
<th>Pnm</th>
<th>Mfg</th>
<th>Gran</th>
<th>Epit</th>
<th>Vzvn</th>
<th>Sink</th>
<th>Grnt</th>
<th>Fibt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp.</td>
<td>0.</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>10</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>10</td>
<td>10</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Control</td>
<td>0.</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* — 0. — Absent  
1. — Present  
** — Koag — coagulum formation  
Pnm — presence of polymorph leukocytes  
Mfg — presence of macrophages  
Gran — presence of granuloma  
Epit — epithelial bridge formation  
Vzvn — connective tissue formation  
Sink — collagen synthesis  
Grnt — presence of granulomatous tissue  
Fibt — presence of fibrous tissue

Granulomatous tissue and fibroblasts, however, were not detected in neither animal from the control group, whereas present in all, or almost all, animals in the experimental group (Table 1). Statistical analysis of the obtained data revealed high statistically significant difference between the experimental and the control group with respect to presence of fibroblasts and granulomatous tissue in the area surrounding the suture material. As regards the presence of macrophages, differences between investigated groups were not statistically significant (Table 2).

Tab. 2 — Significance of the difference in tissue reaction to different suture materials on day 2 post-surgery

<table>
<thead>
<tr>
<th>MFG</th>
<th>.333</th>
<th>.111</th>
<th>.316</th>
<th>2.034</th>
<th>.171</th>
<th>317.56</th>
</tr>
</thead>
<tbody>
<tr>
<td>VZVN</td>
<td>.816</td>
<td>.667</td>
<td>.632</td>
<td>34.421</td>
<td>.000</td>
<td>350.21</td>
</tr>
<tr>
<td>Grnt</td>
<td>1.000</td>
<td>1.000</td>
<td>.707</td>
<td>2630.919</td>
<td>.000</td>
<td>328.29</td>
</tr>
</tbody>
</table>

Cr = .203
Tab. 3 — Prevalence of tissue reaction parameters on day 5 post-surgery

<table>
<thead>
<tr>
<th>Group</th>
<th>Tissue reaction parameters**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Koag</td>
</tr>
<tr>
<td>Exp.</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.</td>
</tr>
<tr>
<td>Control</td>
<td>0.</td>
</tr>
<tr>
<td></td>
<td>1.</td>
</tr>
</tbody>
</table>

* — 0. — Absent  
1. — Present

** — Koag — coagulum formation  
Pnm — presence of polymorph leukocytes  
Mfg — presence of macrophages  
Gran — presence of granuloma  
Epit — epithelial bridge formation  
Vzvn — connective tissue formation  
Sink — collagen synthesis  
Grnt — presence of granulomatous tissue  
Fibt — presence of fibrous tissue

On day 5 post-surgery in all 10 animals from the control and experimental groups the presence of coagulum was observed, i.e. formation of a fibrous clot, as well as presence of polymorphonuclear leukocytes, macrophages, granulomatous and fibrous tissue. Certain differences in tissue reactions were, though, observed with respect to the presence of granuloma in the wound, formation of epithelial bands (epithelial bridge) and connective tissue, as well as collagen synthesis (Table 3). However, statistical analysis of the obtained results revealed statistically significant difference only for the presence of granuloma in the wound (Table 4).

Tab. 4 — Significance of the difference in tissue reaction to different suture materials on day 5 post-surgery

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R2</th>
<th>CHI</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAN</td>
<td>.734</td>
<td>.538</td>
<td>.592</td>
<td>21.000</td>
<td>.000</td>
</tr>
<tr>
<td>EPIT</td>
<td>.229</td>
<td>.053</td>
<td>.224</td>
<td>1.000</td>
<td>.331</td>
</tr>
<tr>
<td>VZVN</td>
<td>.229</td>
<td>.053</td>
<td>.224</td>
<td>1.000</td>
<td>.331</td>
</tr>
<tr>
<td>SinK</td>
<td>.229</td>
<td>.053</td>
<td>.224</td>
<td>1.000</td>
<td>.331</td>
</tr>
</tbody>
</table>

Cr = .216
Tab. 5 — Prevalence of tissue reaction parameters on day 7 post-surgery

<table>
<thead>
<tr>
<th>Group</th>
<th>Tissue reaction rate*</th>
<th>Koag</th>
<th>Pnm</th>
<th>Mfg</th>
<th>Gran</th>
<th>Epit</th>
<th>Vzvn</th>
<th>Sink</th>
<th>Grnt</th>
<th>Fibt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exp.</td>
<td>0.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Control</td>
<td>0.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1.</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

* — 0. — Absent  
1. — Present  
** — Koag — coagulum formation  
Pnm — presence of polymorph leukocytes  
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Vzvn — connective tissue formation  
Sink — collagen synthesis  
Grnt — presence of granulomatous tissue  
Fibt — presence of fibrous tissue

On day 7 post-surgery eight investigated parameters were recorded in all ten experimental animals from both investigated groups (Table 5). Minor divergence between the groups was observed only about the presence of granuloma in the wound (noticed only in one case in the control group), yet this difference was not statistically significant (Table 6).

Tab. 6 — Significance of the difference in tissue reaction to different suture materials on day 7 post-surgery

<table>
<thead>
<tr>
<th>R</th>
<th>R2</th>
<th>CHI</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAN</td>
<td>.229</td>
<td>.053</td>
<td>.224</td>
<td>1.000</td>
</tr>
<tr>
<td>Cr</td>
<td>.183</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comprehensive statistical analysis revealed that on days 5 and 7 both experimental groups exhibited identical characteristics (Table 7), whereas certain variations were observed in the control group (Table 8).

Tab. 7 — Distance in the experimental group between all three days post-surgery

<table>
<thead>
<tr>
<th></th>
<th>Day 2</th>
<th>Day 5</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 2</td>
<td>.000</td>
<td>22.836</td>
<td>22.836</td>
</tr>
<tr>
<td>Day 5</td>
<td>22.836</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>Day 7</td>
<td>22.836</td>
<td>.000</td>
<td>.000</td>
</tr>
</tbody>
</table>

Tab. 8 — Distance in the control group between all three days post-surgery

<table>
<thead>
<tr>
<th></th>
<th>Day 2</th>
<th>Day 5</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 2</td>
<td>.000</td>
<td>10.292</td>
<td>10.831</td>
</tr>
<tr>
<td>Day 5</td>
<td>10.292</td>
<td>.000</td>
<td>1.703</td>
</tr>
<tr>
<td>Day 7</td>
<td>10.831</td>
<td>1.703</td>
<td>.000</td>
</tr>
</tbody>
</table>
DISCUSSION

Analysis of the obtained results suggests that suturing with monofilament synthetic material (nylon) induces more rapid initiation of reparatory and regenerative processes in the body in comparison with the polyfilament natural material (silk). The aforementioned premise is strongly supported by the facts on the presence of connective tissue, i.e. fibroblasts and granulomatous tissue, in the wound sutured with monofilament material. Similar results after parallel testing of several suture materials, carried out on rats in experimental settings, were reported by Okamoto et al.\(^7\)\(^,\)\(^8\) and by other authors.\(^3\),\(^9\),\(^11\),\(^12\).

However, the available data do not confirm effects of the applied suture materials on the persistence of fibrous clot in the wound five days post-surgery, or later. Nevertheless, the obtained results strongly indicate the continual progress of reparatory processes involving all cell elements necessary for an undisturbed wound healing in the group, in which monofilament suture material was used.

In the control group, in which polyfilament natural suture material was used, a delayed activation of reparatory processes is observed. Though such processes were not apparent on day 2 post-surgery, the tissue reaction on day 5 was almost completely equal to the reparatory processes observed after application of monofilament nylon suture. Such a delayed, yet intensified tissue reaction, was described by numerous authors.\(^2\),\(^3\),\(^7\),\(^8\),\(^10\),\(^12\) Formation of granuloma, as an inflammatory reaction associated with the occurrence of giant cells surrounding the foreign body on day 5 post-surgery, can be explained because of multifilament silk material that may enable “wicking” of bacterial organisms in the interstices of the braided structure, as well as marked capillary action associated with liquid absorption and volume changes.\(^4\)\(^–\)\(^6\)

Comparative postoperative analysis of experimentally created wounds sutured with monofilament or polyfilament suture material confirmed more rapid reestablishment of reparatory processes when using monofilament material, reaching the peak value on day 5 and proceeding continually until the end of the investigation period. Application of polyfilament suture material resulted in milder tissue reaction on day 2 post-surgery, reaching the peak value on day 5 and remaining at similar level on day 7 post-surgery, and characterized by slight differences with respect to existence of granuloma. Such observation suggest that polyfilament suture material, after applied into the tissue, induces prolonged and intensive tissue reaction that reaches its peak on day 5 post-surgery. As regards the natural silk material, the tissue reaction is most distinctly reflected through formation of granuloma reach in giant cells, as a reaction to foreign body. This phenomenon is not observed when applying synthetic monofilament suture material.

CONCLUSION

After analyzing the results obtained in experimental model the following conclusions can be made:
1. After placing sutures inside the oral cavity the tissue reaction is manifested as an inflammatory process (even minimal one) occurring from Day 2 to Day 7 post-surgery.

2. After placed into the tissue, the BLACK SILK that belongs to the group of natural polyfilament suture materials produced a prolonged intensive tissue reaction, reaching its peak on Day 5 post-surgery.

3. The most distinct parameter of tissue reaction by using the BLACK SILK was formation of granuloma reach in giant cells associated with the presence of foreign body. Such phenomenon was not observed in monofilament NYLON suture.

4. After placed into the tissue the NYLON, which belongs to the group of synthetic monofilament suture materials, induces short-lasting moderate tissue reaction and rapid reestablishment of reparatory and regenerative processes.

5. After comparing parameters of the intensity or tissue reaction to the investigated suture materials in suturing oral mucosa, we may give certain advantage to the monofilament suture materials.

REFERENCES


УТИЦАЈ РАЗЛИЧИТИХ ВРСТА МАТЕРИЈАЛА ЗА ШИВЕЊЕ НА ИНТЕНЗИТЕТ ТКИВНЕ РЕАКЦИЈЕ УСНЕ ШУПЉИНЕ

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Медицински факултет Нови Сад, Клиника за стоматологију Војводине, Хајдук Вељкова 12, Србија

Резиме
Историјски гледано, за затварање и зашивана хируршког рана коришћени су најразличитији шавни материјали. У стручној медицинској литератури описане су четири основне карактеристике шавног материјала: сигурност чвора, затезна снага, ткивна реакција и сигурност ране. Ткивна реакција приказана је инфламаторном реакцијом која се, макар и минимална, јавља током првих два до седам дана након апликације шавова у ткиво.

Циљ истраживања је био да се испита утицај монофиламентног материјала за шивење (Nylon) на интензитет локалне ткивне реакције у експерименталним условима и упореди с истоветним утицајем употребљеног материјала који се у рутини користи у оралној хирургији (свила).

Испитивање представља проспективну експерименталну студију спроведену на експерименталним пацијентима који су Wistar. Обухваћено је 30 животиња код којих се у горњој вилици као шавни материјал користио Black Syłk дебљине 4-0, а у доњој вилици Nylon дебљине 4-0. За праћење реакције ткива у шавни материјал коришћени су следећи параметри: формирање коагулума, полиморфонуклеарни леукоцити, макрофаги, гранулом, формирање епителног моста, формирање везивног ткива, синтеза колагена, гранулационо ткиво, фибросно ткиво.

Компарирајући параметре интензитета ткивне реакције испитиваних материјала, након сутурирања слузожке усне шупљине, могла би се дати извесна предност синтетским монофиламентним шавним материјалима.

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