PRELIMINARY STUDY
ON BIOLOGICAL AND PHYSICAL PROPERTIES
OF NEW SURGICAL THREADS FOR SOFT TISSUES

RYSZARD MACIEJEWSKI1, MARCIN R. TATARA2, EWA ŚLIWA2, KAMIL TORRES,
ANDRZEJ DĄBROWSKI1, JAY PATEL, MICHAIŁ SOLECKI2,
IWONA ŁUSZCZEWSKA-SIERAKOWSKA3, AND ŁUKASZ ADASZEK4

1Human Anatomy Department, Skubiszewski Medical University of Lublin, 20–074 Lublin, Poland
2II Department of General Surgery, Skubiszewski Medical University of Lublin, 20–081 Lublin, Poland
3Department of Animal Physiology,
4Department of Animal Anatomy, Faculty of Veterinary Medicine,
Agricultural University of Lublin, 20–950 Lublin, Poland
5Department of Epizootiology and Clinic of Infectious Diseases, Faculty of Veterinary Medicine,
Agricultural University of Lublin, 20–612 Lublin, Poland

ewaRST@interia.pl

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Abstract

The aim of the study was to evaluate the physical and biological properties of new surgical threads provided by Matcur, S.A. De C.V., Mexico. The study was performed on 12 piglets of a Polish Large White breed, divided into two equal groups and subjected to surgical procedures at the age of 40 d of life. The first group of animals (control group) was subjected to a sham operation, whereas the experimental group had undergone gastric fundectomy. The fundectomy consisted of cutting out the fundus of the stomach. The soft tissues of the fundectomised stomach were sutured, using catgut quirurgico simple and catgut quirurgico cromico threads. The sham operation consisted of cutting through soft tissues of the abdominal region, which enabled access to the anatomical structures of the stomach, analogically to the experimental group. During the operation procedure, the threads were assessed for the needle penetration and ability to pass through tissues, the tendency to electrify, twisting ability, elasticity, knot stability and tendency to soak up tissue fluids. The mechanical properties of the threads were investigated using an extension test in Lloyd LRX testing machine. Furthermore, haematological and biochemical analyses of the serum were performed 60 d after the surgery. The obtained results showed very high surgical reliability of the investigated threads with no side effects in any of the experimental animals. The wound healing process was characterised by minimal reaction of the soft tissues. The extension test showed very high mechanical endurance of the investigated threads. Moreover, positive results were obtained after the evaluation of knot stability of the threads. Decreased values of haemoglobin, haematocrit, and daily body weight gain of the animals from the experimental group were observed as negative consequences of the fundectomy.

Key words: pigs, soft tissues, fundectomy, surgical sutures.

All materials used in the production of surgical threads must fulfil restrictions imposed by the proper administrative authorities for health protection and control. Polish norms are based on the suggestions of the European and North American pharmacopoeias (1, 2). Normalisation of surgical threads focuses on standardising their production in terms of the basic parameters of numeration as well as durability and length. These requirements also restrict the norms of means of production, sterility, marking, packaging, as well as chemical and biological properties (8-10).

Considering the properties of the material used for production, the surgical threads can be classified into two categories: absorbable and non-absorbable in tissues. Both threads of natural origin (catgut, chromic catgut) and synthetic threads can be used for absorbable sutures. The synthetic threads can be distinguished as monofilaments and polyfilaments, which are made of the polyglycolic acid or polyglactin. Both synthetic monofilaments (polyamide, polyester, polypropylene) and polyfilaments (polyamide, polyester, teflon) can be used for non-absorbable sutures. The natural polyfilament threads such as linen, cotton, and silk can be used for non-absorbable sutures as well. While the cotton and linen threads are tortuous, the silk threads are plaited. As opposite to coated polyamide threads, the polyester and teflon threads are impregnated (3, 16, 17). Considering the fact that a significant percentage of postoperative mortality of patients in surgical units are caused by leakage of surgical junctions within the gastrointestinal tract, the quality of threads used for surgical sutures is the main determinant of the proper processes of wound healing and patient’s survival. Thus, the threads used for ideal surgical junction within the
gastrointestinal tract should provide the maximum blood supply to the sutured stumps, optimal adhesion of the sutured tissues, high mechanical endurance of the junction, and should not disturb the passage of food throughout the gastrointestinal tract (5).

The aim of the study was to investigate physical and biological properties of novel surgical threads with the use of the fundectomised pig model.

Material and Methods

Experimental design and sampling procedure. The experimental procedures used throughout this study were approved by the Local Ethics Committee on Animal Experimentation of the Agricultural University of Lublin, Poland. The study was performed on 12 males of a Polish Large White breed, housed under standard rearing conditions in two indoor pens. The piglets were castrated at the age of 3 d of life and the weaning was performed on the 28th d of life. At the age of 40 d of life, the piglets were divided into two weight-matched groups, and subjected to experimental fundectomy (experimental group; n = 6) or sham-operated (control group; n = 6). The animals were fasted for 24 h before the surgery; however, they were allowed to drink fresh water until 3 h prior to the operation. All surgical procedures were performed on piglets under general anaesthesia. As a pre-anaesthetic medication, the piglets were sedated with an intramuscular injection of ketamine (10 mg/kg of b.w.) until the end of the first week after the operation. Starting on the 8th d after the surgery, the experimental and control animals received full daily dosage of the diet. At the age of 54 d of life, the skin sutures were removed. During the surgical procedures, the reliability of surgical threads and needles was evaluated according to the following parameters:

- needle penetration and thread ability for passing through tissues
- tendency of threads to electrify
- twisting ability of threads
- elasticity of threads and knot stability
- tendency of threads to soak up the tissue fluids
- susceptibility to twisting of the loosely arranged thread

Knot stability was investigated with the use of the previously reported method (6, 7). Ten carefully tightened knots made of the evaluated threads were tied on rubber tubes of 1 cm in diameter and 15 cm length, at the rate of ten knots made from the same material per one tube dispersed at the interval of 1 cm. The tubes with the knots were then dipped in distilled water and put in a thermostat at 37°C for 24 h. After that, the loosened knots of each kind of tested threads were counted. Mechanical evaluation of the investigated threads was performed in Lloyd LRX testing machine (Lloyd Instruments Ltd, Fareham, UK). The value of maximum strength (F_{max}) of the investigated threads with or without the node at 50% of sample length was determined using the extension test. Haematological parameters assessment and biochemical analysis of serum was performed 60 d after the surgery. Next to the serum activity of aspartate aminotransferase (AspAT), alanine aminotransferase (AlAT), alkaline phosphatase (ALP), the concentrations of glucose, total protein, urea, creatinine, and bilirubin, were determined. According to the international standards, which set the minimal period to observe the animals for this kind of experiments at the mark of six months, the animals were sacrificed at the age of 8 months of life. Furthermore, post-mortem examination of the stomach was performed.

Statistical analysis. All the data are presented as means ± SEM. Differences between means were tested for statistical significance with the use of Student’s t-test. Data were found to be normally distributed according to Kolomogorov-Smirnov test. Differences showing P≤0.05 were considered statistically significant.

Results

The results of intra-operative observations showed that all the features, which characterise the reliability of surgical threads and needles obtained very high scores. Both needle penetration and the ability of thread to pass through tissues was very good with a minimal tendency to electrify. The elasticity of threads and the stability of knots were very good, as well.
Furthermore, neither the tendency to soak up the tissue fluids, nor the susceptibility to twisting of the loosely put thread was observed. At the age of 6 months from the surgery, all the postoperative wounds were healed by first intention. During the experiment lasting, all the animals showed proper levels of activity and non-disturbed appetite. Post-mortem examination did not show any pathological changes within the sutured region of the stomach, proving that the healing processes of all the wounds occurred in a physiologically proper way and were not disturbed by the presence of the sutures (Fig. 1B).

The final body weight of the animals from the control group was significantly higher than that in the fundectomised animals. The difference in body weight between the groups reached nearly 200% (P < 0.001). During the whole period of the study, one case of abdominal hernia occurred after 2 months from the surgical procedure in a pig from the fundectomised group. The investigation of knot stability after 24 h incubation at 37°C did not show any loosened knots of any kind of the tested threads. The results of haematological and biochemical analysis of serum in pigs at the age of 100 d of life are presented in Table 1.
Table 1
Haematological parameters and biomechanical analysis of serum in 100-d-old pigs from the experimental and control groups

<table>
<thead>
<tr>
<th>Investigated parameter</th>
<th>Control group (n = 6)</th>
<th>Experimental group (n = 6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red blood cells (1012/L)</td>
<td>7.614 ± 0.247</td>
<td>7.263 ± 0.294</td>
</tr>
<tr>
<td>Haematocrit (%)</td>
<td>37 ± 1.7*</td>
<td>31 ± 1.7</td>
</tr>
<tr>
<td>Haemoglobin (g/dL)</td>
<td>11.72 ± 0.61*</td>
<td>9.62 ± 0.47</td>
</tr>
<tr>
<td>White blood cells (109/L)</td>
<td>18.98 ± 0.84</td>
<td>17.74 ± 1.81</td>
</tr>
<tr>
<td>Thrombocytes (109/L)</td>
<td>377.4 ± 26.4</td>
<td>334.2 ± 56.1</td>
</tr>
<tr>
<td>Alanine aminotransferase (IU/L)</td>
<td>40.7 ± 5.29</td>
<td>35.5 ± 4.18</td>
</tr>
<tr>
<td>Aspartate aminotransferase (IU/L)</td>
<td>66.5 ± 6.83</td>
<td>56.6 ± 7.36</td>
</tr>
<tr>
<td>Alkaline phosphatase (IU/L)</td>
<td>192 ± 18</td>
<td>175 ± 21</td>
</tr>
<tr>
<td>Urea (mmol/L)</td>
<td>5.98 ± 0.47</td>
<td>5.75 ± 0.41</td>
</tr>
<tr>
<td>Creatinine (µmol/L)</td>
<td>201 ± 8</td>
<td>211 ± 12</td>
</tr>
<tr>
<td>Total bilirubin (µmol/L)</td>
<td>2.91 ± 0.29*</td>
<td>3.82 ± 0.19</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td>3.47 ± 0.21</td>
<td>3.56 ± 0.24</td>
</tr>
<tr>
<td>Total protein (g/L)</td>
<td>51.8 ± 3.0</td>
<td>50.3 ± 2.3</td>
</tr>
</tbody>
</table>

*P<0.05.

Table 2
Values of maximum strength (Fmax) of the investigated threads with or without node at 50% of sample length

<table>
<thead>
<tr>
<th>Investigated thread</th>
<th>Size</th>
<th>Fmax of thread with node at 50% of sample length (N)</th>
<th>Fmax of thread without node (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matcat catgut quirurgico cromico 4/0</td>
<td>4/0</td>
<td>8.30 ± 1.03</td>
<td>9.71 ± 1.11</td>
</tr>
<tr>
<td>Matcat catgut quirurgico cromico 5/0</td>
<td>5/0</td>
<td>4.09 ± 0.48</td>
<td>5.93 ± 0.61</td>
</tr>
<tr>
<td>Matcat catgut quirurgico simple 4/0</td>
<td>4/0</td>
<td>8.13 ± 0.98</td>
<td>12.67 ± 1.33</td>
</tr>
<tr>
<td>Matcat catgut quirurgico simple 6/0</td>
<td>6/0</td>
<td>3.11 ± 0.27</td>
<td>4.62 ± 0.50</td>
</tr>
<tr>
<td>Masted seda negra trenzada 4/0</td>
<td>4/0</td>
<td>7.97 ± 0.70</td>
<td>9.68 ± 1.02</td>
</tr>
<tr>
<td>Masted seda negra trenzada 5/0</td>
<td>5/0</td>
<td>3.26 ± 0.21*</td>
<td>5.66 ± 0.25</td>
</tr>
<tr>
<td>Masted seda negra trenzada 6/0</td>
<td>6/0</td>
<td>2.39 ± 0.11</td>
<td>3.21 ± 0.12</td>
</tr>
<tr>
<td>Manty monofilamento de nylon 5/0</td>
<td>5/0</td>
<td>2.99 ± 0.13*</td>
<td>6.64 ± 0.43</td>
</tr>
<tr>
<td>Matpileno monofilamento de polipropileno 4/0</td>
<td>4/0</td>
<td>5.90 ± 0.49*</td>
<td>12.01 ± 0.99</td>
</tr>
<tr>
<td>Matpileno monofilamento de polipropileno 5/0</td>
<td>5/0</td>
<td>4.09 ± 0.38</td>
<td>6.78 ± 0.89</td>
</tr>
<tr>
<td>Matpileno monofilamento de polipropileno 6/0</td>
<td>6/0</td>
<td>1.65 ± 0.21</td>
<td>2.73 ± 0.30</td>
</tr>
</tbody>
</table>

*P<0.05.

Sixty days after the surgical procedure, the values of haematocrit and haemoglobin concentration were significantly decreased in piglets subjected to fundectomy (P<0.01). Furthermore, the serum concentration of total bilirubin was significantly increased by 31.3% in the fundectomised group of animals, when compared to the sham-operated controls (P=0.02). Mechanical evaluation of threads showed that the samples with or without node at 50% of their length reached similar values of the maximum strength (Table 2). Furthermore, it must be underlined that all samples with the node at 50% of their length were ruptured just below or under the node, confirming a very high mechanical endurance of the investigated threads.

Discussion

The results obtained from both the intraoperative and the postoperative evaluation showed that the investigated threads are suitable for use in surgical procedures on the soft tissues in pigs. It was showed that all the features, which characterise the reliability of surgical threads and needles have reached very high scores. It is worth to underline that neither postoperative complications nor leaks of the sutured tissues were stated. Considering species-related susceptibility of pigs to abdominal hernia, one case of abdominal hernia observed after two months from the surgery in a pig from the fundectomised group seems to be a very good result. This statement is confirmed by the results of the mechanical evaluation of the investigated threads with the use of the extension test. This analysis showed similar values of the maximum strength in samples with or without a node tied at 50% of their length, confirming very high mechanical endurance of the investigated threads. Very good knot stability observed 24 h after the thread incubation at 37°C is also noteworthy.

The results of haematological evaluation preformed in pigs two months after the surgery did not show any significant differences of the white blood cell (WBC) count between the sham-operated and the fundectomised groups. The values of WBC count obtained at the two month mark were within the range of
physiological norms, suggesting very high biocompatibility of the threads used in the experiment, even though the period of 60 d between performed surgery and haematological examination can be considered as relatively short. Furthermore, the results of the WBC analysis obtained during this study, are comparable with those obtained in other studies with the use of this breed of pigs (4, 15). The analysis of haematocrit value and haemoglobin concentration showed that fundectomy in pigs significantly decreased both these parameters. These effects may be explained by a decreased absorption of iron as a direct consequence of the procedure. This hypothesis seems to be strongly supported by other results obtained in gastrectomised pigs. Next to a decreased body weight gain in gastrectomised pigs, the lowered concentration of haemoglobin was observed by Zilling et al. (18) when compared to the results obtained in sham-operated animals. However, in contrast to our studies, Zilling et al. (18) found a decreased total protein concentration as a result of the gastrectomy (18). Investigations in humans showed that total or partial resection of the stomach may lead to inhibition of the haematopoiesis. The disturbance of iron absorption resulted in anaemia in 30-60% of patients subjected to gastric surgery (12). Moreover, the analysis of serum concentration of the investigated parameters were stated between the groups. Furthermore, the results of biochemical analysis of serum, no significant differences of the investigated parameters were stated between the groups. Moreover, the analysis of serum concentration of urea and creatinine indicated that fundectomy did not negatively influence the renal functions (15). The differences in final body weight value observed as the result of the fundectomy are in accordance with other investigations. Morohashi et al. reported decreased body weight values in rats subjected to experimental gastrectomy (11). In other studies on rats, the experimental gastrectomy significantly reduced body weight gains and final body weight values (13). The decrease of body weight values was also present in humans subjected to gastric surgery as a consequence of the neoplastic processes (12, 14).

In conclusion, the results obtained showed that the investigated threads are suitable for use in surgical procedures on soft tissues in pigs. It was showed that all the features which characterize the reliability of the surgical threads and needles reached very high scores. Furthermore, the investigated threads did not induce negative tissue or overall systemic reactions. The surgical wounds were healed by the first intention process with minimal local tissue reaction confirming very good biocompatibility of the threads used in the experiment. Post-mortem examination of the stomach confirmed these observations. The mechanical evaluation showed very high mechanical endurance and knot stability of the investigated threads. The decreased values of haemoglobin, haematocrit, and daily body weight gain of the animals from the experimental group were observed as negative consequences of the fundectomy.

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References