Histopathological Comparison of Mosquito Net with Polypropylene Mesh for Hernia Repair: An Experimental Study in Rats

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Abstract Use of mosquito net, in place of polypropylene mesh, had been reported for tension-free hernia repair, as a better cost-effective option. This experimental histopathological study was performed in rats to find out the tissue response and the foreign body reaction and its comparison between commercial polypropylene mesh and the sterilized mosquito net. This experimental study was conducted in the Department of Surgery, Government NSCB, Medical College, Jabalpur (Madhya Pradesh), India. It was carried out in 40 albino rats. A 1.5×0.5-cm hernial defect was created by excising full-thickness abdominal wall muscle. All rats underwent on-lay mesh repair of hernial defect (polypropylene mesh, $n=20$; mosquito net, $n=20$). Half of rats in each group were sacrificed on day 14, and the other half, on day 90. Sections of containing mesh were examined histopathologically for inflammatory infiltrate, giant cells, and collagen deposition. Mosquito net group showed significantly greater number of giant cells and inflammatory cells at 14 and 90 days ($p<0.0001$, $p<0.001$, $p<0.05$, and $p<0.001$, respectively), as compared to polypropylene group. Grades of collagen fiber deposition were almost equal in both groups, both at 14 and 90 days ($p>0.05$ and $p>0.05$, respectively). Results of mosquito net are comparable to conventional polypropylene mesh. In a setup, where cost-

effectiveness is of primary importance, use of mosquito net for tension-free hernia repair can be an acceptable alternative as proven histologically, to commercially available polypropylene mesh.

Keywords Hernia · Histological study · Mosquito net

Background

Tension-free mesh repair has become the standard accepted operating procedure for all types of groin and incisional hernias [1]. Use of polypropylene mesh is very common for this purpose, but it carries the inherent cost constraint of the material, which may be a limitation for its use in the developing countries. There are a few studies which had reported the use of mosquito net, in place of polypropylene mesh as a more cost-effective, but equally efficacious option [2–6].

This experimental histopathological study was performed in rats to find out the comparison of tissue response and foreign body reaction between commercial polypropylene mesh and sterilized mosquito net.

Method

This experimental study was conducted in the Department of Surgery, Government NSCB Medical College, Jabalpur (Madhya Pradesh), India. It was carried out in 40 albino rats after obtaining due permission from the Institutional Animal Ethics Committee.

Under general anesthesia by open ether technique, a midline 2-cm vertical incision was made on abdominal skin. A 1.5×0.5-cm hernial defect was created by excising full-thickness abdominal wall muscle. All rats underwent on-lay

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mesh repair of hernial defect (polypropylene mesh, $n=20$; mosquito net, $n=20$).

Mosquito net used was of monofilament fiber which is a high-density copolymer of polypropylene and polyethylene [2]. It was supplied for this study by Dr. B. V. Reddy in sterilized packing.

Mosquito net had similar properties to polypropylene. It was made of monofilament fiber which is a high-density copolymer of polypropylene and polyethylene; with peak melting temperature of 144.59 °C and a tensile strength of 225 kg/cm² (ARAI). It was a plain mosquito net cloth, without any additional chemical treatment and easily autoclaved. Pore size of Indian mosquito net is 1–2 mm.

Polypropylene (Prolene, Johnson & Johnsons) mesh is available in the market as presterilized pack with pore size of 600 µm.

On-lay mesh (3×1 cm) was placed over muscle defect and sutured with 4-0 Prolene suture. Skin was repaired with 3-0 silk. Ciprofloxacin 8 mg/kg bodyweight was given for 5 days to all rats.

Rats were allowed regular food and water afterwards, ad libitum. Rats were kept under observation for wound infection and were divided into four groups as follows:

1. Pm 14—rats with Prolene mesh, sacrificed on day 14 ($n=10$).
2. Pm 90—rats with Prolene mesh, sacrificed on day 90 ($n=10$).
3. Mn 14—rats with mosquito net, sacrificed on day 14 ($n=10$).
4. Mn 90—rats with mosquito net, sacrificed on day 90 ($n=10$).

After sacrificing the rats, a 4×2-cm specimen of abdominal wall containing mesh was harvested. It was examined histopathologically after hematoxylin and eosin staining. Evaluation was done for the following:

1. Inflammatory infiltrate: Number of inflammatory cells per high power field at tissue per prosthesis interface was assessed in every specimen.
2. Giant cells: Number of giant cells per high power field was histologically evaluated at tissue per prosthesis interface in every specimen.
3. Collagen deposition: Percentage of collagen deposition per high power field was graded and assessed in every specimen.

The measurement of collagen deposition was done by distributing the collagen deposition into different grades for ease of calculation, according to Table 1.

In Pm 90 group, 30 % cases show grade 2 collagen deposition; 40 % cases, grade 3 collagen deposition; and 30 % cases, grade 4 collagen deposition. In group Mn 90, 20 % cases show grade 1 collagen deposition; 20 % cases,

Table 1 Collagen deposition

Grades	0	1	2	3	4	5
Collagen (% field)	0	<20	20–40	40–60	60–80	80–100

grade 2 collagen deposition; and 40 % cases, grade 4 collagen deposition.

There was no major difference of collagen deposition in both groups.

Average cell count per high power field was done in every specimen. Mean of all observation in one group was taken as mean rank of that group and compared for each group.

Statistical analysis of histological results was performed using SPSS 17th (Chicago, USA) software package.

Mann–Whitney *U* test for parametric and nonparametric variables were performed. Differences were considered significant at $p<0.05$.

Results

All 40 rats had primary wound healing. On histopathological examination, mosquito net group showed significantly greater number of giant cells at 14 and 90 days ($p<0.0001$ and $p<0.001$, respectively), as compared to polypropylene group. Similarly, mosquito net group showed significantly greater number of inflammatory cells, both at 14 and 90 days ($p<0.05$ and $p<0.001$, respectively), as compared to polypropylene group (Fig. 1). However, grades of collagen fiber deposition were almost equal in mosquito net and polypropylene groups, both at 14 and 90 days ($p>0.05$ and $p>0.05$, respectively) (Table 2).

Discussion

Low-cost indigenous alternatives are developed in the face of resource constraints and are used in almost every field in the developing countries, and abdominal closure and even laparoscopic hernia surgeries are no exceptions [7–9]. One of the first experimental studies using indigenous knitted nylon mesh to repair large abdominal defects, in dogs, showed comparable tensile strength and inflammatory fibrous reaction [10]. Tongaonkar et al. [2] in their landmark study showed that mosquito net had similar properties to polypropylene. There was not a single rejection out of 419 meshes used in 403 patients. Similar good results with remarkable cost advantage over commercially available polypropylene mesh have been reported by others since then [3–6].

Such acceptable results prompted the question of foreign body reaction to indigenous mosquito net. Wilhelm et al.

Fig. 1 Histological image of mesh reaction. H&E stain

studied the nylon mesh in 12 goats and found that after 16 weeks, foreign body granulomas in the mosquito net group contained a higher proportion of inflammatory tissue ($p=0.007$) and more giant cells ($p=0.003$) [11]. However, these microscopically observed more intense inflammatory reactions did not correlate with healing complications such as infection, fistula, and seroma; and clinically observed wound healing was free of complications.

The present study revealed similar outcome with significantly greater giant and inflammatory cells in mosquito net group, but grade of collagen deposit was almost identical between mosquito net and polypropylene groups (Table 1), suggesting similar wound strength between the two groups.

Logic and few clinical studies about acceptance of mesh hernioplasty indicate the superiority of lightweight meshes and their association with better pain scores and better patient comfort [12]. However, many other studies, including a meta-analysis, have shown no difference between pain and quality of life among different types of meshes [13, 14].

Mosquito net, being a copolymer of polyethylene, exhibits the similar properties of commercial meshes. Sanders et al. assessed the polymer type, filament characteristics, pore size, weight, linear density, elasticity, and tensile strength of mosquito net and compared it with commercial meshes and found that the material and mechanical properties of the polyethylene mosquito net are substantially equivalent to those of

Table 2 Comparison of histological features of different groups and their significance

Histological features	Group	Mean rank	Significance	Group	Mean rank	Significance
Giant cells	Pm 14	5.75	$p<0.0001$	Pm 90	6.25	$p<0.001$
	Mn 14	15.25		Mn 90	14.75	
Inflammatory cells	Pm 14	7.80	$p<0.05$	Pm 90	6.45	$p<0.001$
	Mn 14	13.20		Mn 90	14.55	
Grade of collagen deposit/HPF	Pm 14	10.50	$p>0.05$	Pm 90	11.50	$p>0.05$
	Mn 14	10.50		Mn 90	9.50	

commonly used lightweight commercial meshes [15]. These meshes can be easily sterilized by steam autoclaves without the loss of their properties [16].

Hernia repair with mosquito net mesh is a plausible, safe, cost-effective alternative in low-income countries.

Sørensen, in his recent review of all studies on mosquito net, found good short- and long-term outcomes with noncommercial meshes for open inguinal hernia repair which is highly cost-effective especially in a resource-limited setting [17].

Clearly, the final word has not been heard on this topic, and ultimately, the choice of mesh will depend on surgeon's preference and cost of the mesh. The present experimental study shows that results of mosquito net are comparable to conventional polypropylene mesh in rats. Both mosquito net and polypropylene provide sufficient strength to abdominal wall, but mosquito net evokes more intense inflammatory reaction and foreign body giant cell reaction, but clinically, there were no graft rejection and wound complications. These results in rats can be easily implemented in human being for the use of mosquito net as both mammals have similar genome as compared to other mammals [18].

One of the major advantages is cost-effectiveness. In a setup where cost-effectiveness is of primary importance, use of mosquito net found to be suitable experimentally for tension-free hernia repair.

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