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Review Article

An Update on the Open Mesh-Based Inguinal Hernia Repair: Review Article

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Abstract: The open mesh-based inguinal hernia repairs are now the most common hernia repair techniques and have replaced the suture-based repairs. Lichtenstein repair is the most common repair technique as it has a short learning curve and can be performed under local anesthesia. It is associated with reduced postoperative morbidity, and it has the lowest recurrence rate. The Plug and Patch and the Prolene hernia system are alternative open mesh-based repairs that can be performed for open inguinal hernia repair. In this review, we will look at the Lichtenstein repair, the Plug and Patch repair, and the Prolene hernia system, looking at the indications and complications. We will also compare these procedures regarding their postoperative complications and recurrence rates.

Keywords: "Chronic pain", "Lichtenstein"," Mesh Fixation"," Mesh", "Plug and Patch", "Prolene Hernia System", and "Open Repair".

INTRODUCTION

Inguinal hernia repair is one of the most common surgical operations that is performed in the general surgical unit. Male patients account for more than 90% of inguinal hernia repairs, with female patients accounting for 10%. The peak incidence for male patients is in the 60 to 80-year age group. (Burcharth *et al*., 2013). The open inguinal hernia repairs can be divided into the suture-based repairs, like the Bassini, Halstead, and Shouldice techniques, and the mesh-based repairs, like the Lichtenstein, the plug and patch, and the Prolene hernia system (Awad & Fagan, 2004). The Lichtenstein repair is now the most common open inguinal hernia repair, since Irving Lichtenstein presented his findings in 1986. This repair has been described as a tension-free repair, as the posterior wall of the inguinal canal is reinforced with a synthetic mesh, and this reduces the postoperative pain and encourages early ambulation (Amid, 2005; Bittner & Schwarz, 2012; Faylona, 2017; Morrison, 2018). The other variants of the open mesh repair include the plug and patch repair, which was popularized by Rudkow and Robbins, and the Prolene Hernia System. The kugel patch repair, where a piece of mesh is placed in the pre-peritoneal space, is also included under this type of repair (Antoniou *et al*., 2014).

The HerniaSurge guidelines have recommended that the mesh-based inguinal hernia techniques be used for the management of inguinal hernias, with the Lichtenstein repair, which utilizes flat mesh to reinforce the posterior wall of the inguinal canal, as the operation of choice. The plug and patch and the Prolene hernia system have not been recommended because of the excessive use of foreign material and the increased cost (Tran, 2018). An update of the international HerniaSurge guidelines has recommended the Lichtenstein repair for primary inguinal hernias in addition to the laparoscopic repairs like the transabdominal preperitoneal (TAPP) and total extraperitoneal (TEP). They have also recommended the use of lightweight mesh to reduce the risk of complications like chronic pain (Stabilini *et al*., 2023). The European Hernia Society has also recommended that the Lichtenstein repair be recommended for the surgical repair of primary unilateral inguinal hernias in adults, with the lightweight mesh being considered for the

reduction of complications like chronic pain (Simons *et al*., 2009).

In this review, we will look at the common mesh-based inguinal hernia repairs, which include the Lichtenstein repair, the plug and patch repair, and the Prolene Hernia System. We will also look at the complications, like chronic pain and recurrence rate. We will also look at the types of mesh and the mesh fixation techniques. We conducted a literature review using PUBMED, Cochrane database of clinical reviews, and Google Scholar, looking for clinical trials, observational studies, cohort studies, systematic reviews, and meta-analyses from 1980 to 2025. We used the following keywords: "open repair", "mesh", "Lichtenstein", "Plug and patch "," Prolene hernia system "," chronic pain", and "mesh fixation". All articles were in the English language only. Further articles were obtained by manually cross-referencing the literature. Case reports and studies with fewer than 10 patients and editorials were excluded. Adult male and female patients were included in this study, and pediatric patients were excluded.

DISCUSSION

The Lichtenstein Tension-Free Inguinal Hernia Repair

Irving Lichtenstein introduced this tension-free repair in 1984, whereby after reduction of the hernia and ligation of the sac, a mesh was inserted and reinforced on the posterior wall of the inguinal canal, and it was fixed to the inguinal ligament and conjoint tendon with non-absorbable sutures and under no tension. Lichtenstein used this technique in 1000 patients and followed them for up to 5 years, and he reported no recurrence (Lichtenstein *et al*., 1998). Amid *et al*., made minor alterations to the Lichtenstein repair by performing it under local anesthesia. Identifying the ilioinguinal, iliohypogastric, and genital branch of the Genito-femoral nerve during the dissection of the sac, and using a larger mesh (10cm by 15cm) with an overlap of 2 to 3cm over the pubic tubercle and 2 to 4cm beyond the Hasselbach triangle, the lower end of the mesh is anchored with continuous non-absorbable sutures and in the upper end interrupted sutures are used. A total of 4000 Lichtenstein repairs were performed, and after a follow-up of ten years, there were only 4 recurrences (Amid *et al*., 1995). The evolution of the Lichtenstein repair has seen it being incorporated into the primary repair of inguinal hernias, and the British Hernia Centre performed a total of 3175 repairs with a wound hematoma rate of 2% and a wound infection rate of 1.3% (Kurzer *et al*., 2003).

The recurrence rate following the Lichtenstein repair was assessed by Sakorafas *et al*., where 540 repairs were performed, and after a follow-up of 3.8 years, the recurrence rate was 0.2%. There were also low hematoma and seroma formation rates after surgery (Sakorafas *et al*., 2001). Amid *et al*., proposed that to reduce the recurrence rate, a larger-sized mesh, of 7.5cm by 15cm, should be used to extend beyond the boundaries of the inguinal canal and to account for mesh shrinkage. Crossing the tail of the mesh to prevent recurrence and positioning the mesh in a dome-shaped configuration. Identification of the iliohypogastric, ilioinguinal, and preservation of the external spermatic vein that protects the genital nerve (Amid, 2003).

Messias *et al*., recommended ten steps to optimize the outcomes in the Lichtenstein repair, which include identification of the ilioinguinal, iliohypogastric, and genital branch of the genitofemoral nerve. Comprehensive and meticulous dissection. Pragmatic neurectomy should be performed in case of nerve injury. Protecting the cremasteric fascia and visualizing the external spermatic vein, femoral canal assessment to prevent missed femoral hernia, management of the hernia sac, if it is direct, indirect, or inguinoscrotal, choosing the appropriate mesh, including characteristics, correct mesh fixation, proper mesh size, and overlapping with wide dissection, and duration of convalescence (Messias *et al*., 2023, 2024).

Bisgaard *et al*., compared the risk of recurrence after 5 years of the Lichtenstein repair against sutured repairs. A total of 47,975 patients who underwent inguinal hernia repair were taken from the Danish hernia database, and the recurrence rate from the Lichtenstein repair was significantly lower than the sutured repair (Bisgaard *et al*., 2007).Verstraete *et al*., looked at the long-term follow-up of patients who underwent the Lichtenstein repair for inguinal hernias. A total of 142 patients who underwent the Lichtenstein repair were followed up for 3 years, and the recurrence rate was 0.7%(Verstraete & Swannet, 2003).

Chronic pain is another complication that is seen after the Lichtenstein repair, and it is defined as pain in the operative site after three months. A prospective study by Jaiswal *et al*., included 454 patients who had undergone the Lichtenstein repair, and after a follow-up of 18 months, the incidence of chronic pain was 0.78%(Jaiswal, 2009).A meta-analysis of randomized controlled trials on the incidence of chronic groin pain following open mesh inguinal hernia repair was conducted by Charalambous *et al*., Nine trials with 1510 patients were included in this study, and the incidence of chronic pain was 4.8% after one year(Charalambous & Charalambous, 2018). Some of the risk factors for chronic pain after mesh repair include increasing age of the patient, the presence of pain before surgery, large inguinal-scrotal hernias, and the type of mesh used (Pierides *et al*., 2016).

The method of mesh fixation for chronic pain was assessed by a systematic review and meta-analysis comparing sutured mesh fixation against glue fixation for open inguinal hernia repair. A total of 4 trials with 1115 patients were included in this study, with 553 undergoing glue fixation and 562 undergoing sutured

fixation. There were no differences in postoperative morbidity and pain between the two types of fixation, except that the glue fixation had a shorter operative time (Ladwa *et al*., 2013). Another systematic review and meta-analysis comparing glue fixation with sutured fixation for the Lichtenstein repair for primary inguinal hernia repair by Phoa *et al*., also concluded the same (Phoa *et al*., 2022) A network meta-analysis on the mesh fixation techniques for the Lichtenstein repair was conducted by Jiang *et al*., A total of 32 studies with 6362 patients were included in this study, and glue fixation of the mesh was associated with reduced postoperative infection and chronic pain; however, large-scale randomized controlled trials may be required to confirm this (Jiang *et al*., 2022).

The Plug and Patch Repair for Inguinal Hernia

This repair involves the use of a mesh plug that is inserted in the preperitoneal space and anchored to the tissues with non-absorbable sutures, and then a standard flat mesh is placed over the posterior wall of the inguinal canal while making a slit for the cord structures, and it is anchored to the inguinal ligament and conjoint tendon with non-absorbable sutures. This procedure can be done under local anesthesia and is associated with good short-term complication rates, such as hematoma and seroma formation (Bringman *et al*., 2000.). Rutkow popularized this procedure as the Prefix plug repair, and in his series, 4044 patients who had undergone this procedure over a period of 15 years and it was associated with a success rate of 89% and a recurrence rate of 11% (Rutkow, 2003). Zieren *et al*., performed the plug and patch repair on 400 patients with inguinal hernias under local anesthesia, and the most common complications were seroma and hematoma formation, and the recurrence rate was 0.25% (Zieren *et al*., 2001).

A prospective double-blind randomized controlled trial of short-term outcomes on the Lichtenstein repair and the Perfix plug and patch repair for inguinal hernias was conducted by Kingsnorth *et al*., A total of 141 patients were randomized to 68 who underwent the Lichtenstein repair and 73 who underwent the plug and patch repair. The plug and patch were associated with a smaller skin incision and reduced operative time, but the post-operative morbidity was similar between the two groups (Kingsnorth *et al*., 2000).Some of the complications that arise from the plug and patch repair include migration or dislodgement of the mesh, shrinkage of the mesh that can lead to recurrence and chronic pain (LeBlanc, 2001).

Prolene Hernia System for Inguinal Hernia Repair

The Prolene hernia system is a bilayer mesh that was designed by Gilbert in 1997 for the treatment of all types of inguinal hernias. The polypropylene bilayer connected mesh has three components: a flat, round underlay, an elongated oval-shaped overlay, and a 1.5cm round connector that joins these in the center. The Prolene hernia system will require dissection of the preperitoneal space to insert the underlay component. The overlay component is placed in the posterior wall of the inguinal canal and sutured in place. The procedure can be performed under local or regional anesthesia. The advantage of the Prolene hernia system is that it reinforces the anterior and the pre-peritoneal space to prevent recurrence (Gilbert & Miami, 1992.; Mayagoitia, 2004; Young & Gilbert, 2018).

Berende *et al*., retrospectively assessed the Prolene hernia system in 178 patients with a primary inguinal hernia, and the wound infection rate was 1.3%, the hematoma rate was 1.3% and at a median follow-up of 32 months, the recurrence rate was 2.6% (Berende *et al*., 2007).Faraj *et al*., looked at the five-year results of the inguinal hernia treatment with the Prolene Hernia System. A total of 158 patients were followed up on the recurrence rate was 2.3% and the chronic pain rate was 1.8% (Faraj *et al*., 2010). Another study by Hasegawa *et al*., who also looked at the long-term outcomes after hernia repair with the Prolene Hernia System, and a recurrence rate was 1.8%(Hasegawa *et al*., 2006).Yener *et al*., looked at the long-term quality of life of the Prolene hernia system in patients who had undergone hernioplasty, and the recurrence rate after follow-up of eight years was 3.3%(Yener *et al.,* 2012).

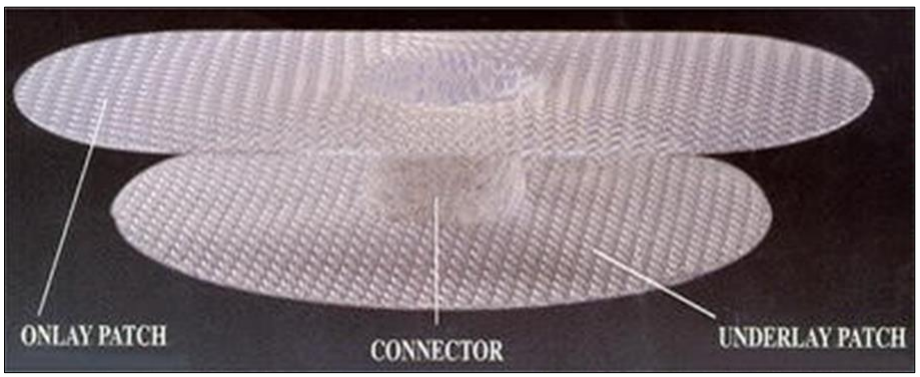

Image Ⅰ: The Prolene Hernia System

Comparison of the Lichtenstein Repair with the Plug and Patch and Prolene Hernia System

Frey *et al*., conducted a randomized clinical trial comparing the Lichtenstein repair with mesh plug for primary inguinal hernias. 595 patients were randomized to 297 who underwent the Lichtenstein repair and 298 who underwent the plug mesh repair. At 12 months follow-up, there were no significant differences in the recurrence and post-operative complications between the two procedures(Frey *et al*., 2007)Zhao *et al*., conducted a meta-analysis of randomized controlled trials comparing the open mesh techniques for inguinal hernia repair. Ten trials with 2708 patients were included in this study, and there were no significant differences in the recurrence rate between the Lichtenstein, plug mesh, and Prolene hernia system (Zhao *et al*., 2009).

Another prospective randomized controlled trial comparing the Lichtenstein repair, plug and patch, and the Prolene hernia system for primary inguinal hernia repair, which was the BOOP study (Bi-layer and connector, On-lay, and On-lay with Plug for inguinal hernia repair) was conducted by Dalenback *et al*., A total of 475 patients were included in this study and after a follow up of three years there were no significant differences with regards to post operative morbidity and recurrence rates between the procedures, although the plug mesh and the Prolene hernia system had a shorter operative time than the Lichtenstein repair(Dalenbäck *et al*., 2009).

A meta-analysis comparing the mesh-plug repair with the Lichtenstein repair in the treatment of primary inguinal hernia was conducted by Yu *et al*., A total of 11 studies with 2929 patients were included, with 1457 patients undergoing the plug mesh repair and 1472 patients undergoing the Lichtenstein repair. The plug mesh repair was associated with a shorter operative time, but there were no significant differences in the postoperative morbidity and recurrence rates (Yu *et al*., 2021).A meta-analysis comparing the Prolene hernia system and the Lichtenstein repair was conducted by Decker et al. A total of 7 studies with 1377 hernia repairs were included in this study, and with a mean follow-up of 92 months, there was no difference in the postoperative complications and recurrence rates, with the Prolene hernia system having a shorter operative time(Decker *et al*., 2019).A similar meta-analysis comparing the Prolene hernia system and the Lichtenstein repair for inguinal hernia repair by Sanjay *et al*., also concluded that both the Prolene hernia system and the Lichtenstein repair were effective in the management of inguinal hernia(Sanjay *et al*., 2012).

Table I

Study	Study Type	Year	N=numbers	Lichtenstein recurrence rate (%)	Prolene hernia system recurrence rate (%)	Mesh Plug Repair recurrence rate (%)
Dalenback *et al*.,	Prospective randomized controlled trial (RCT)	2008	472	1.3%	1.9%	1.3%
Nienhuijs *et al*.,	Randomized study	2014	270	5.6%	3.3%	9.9%
Decker *et al*.,	Meta-analysis	2018	1377	0.8%	0.5%	
Miao Yu *et al*.,	Meta-analysis	2021	2929	2.6%		2.8%

The table shows the recurrence rates between the Lichtenstein repair, Prolene Hernia System, and the mesh plug repair.

CONCLUSION

The Lichtenstein repair is the best open mesh-based inguinal hernia repair, as it can be performed under local anesthesia, is cost-effective, and has a short learning curve. The recurrence rate is the lowest among all the other open-based inguinal hernia repairs. Chronic pain is now the most common morbidity that arises from this type of repair, but with better types of mesh, like lightweight mesh and better fixation techniques like glue fixation, it is hoped that the rate of chronic pain will reduce. The Plug and Patch repair and the Prolene hernia system are alternative mesh-based repairs that can be considered in some patients, but they are associated with increased cost, and the outcomes are like the Lichtenstein repair. The recurrence rates are similar between these three procedures, so choosing which repair is often done by the treating surgeon.

Conflict of Interest: There is no conflict of interest

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