

The Current status of Open inguinal hernia repair in Adults: Narrative Review article

Abstract

Open inguinal hernia repairs are a common general surgical procedure, and it can be divided into mesh-based repairs and sutured based repairs. Mesh-based repairs are the most popular open inguinal hernia repair with the Lichtenstein repair being the most common surgical procedure. The sutured based repairs are not as commonly performed with the Shouldice repair being the most popular repair, but the Desarda repair is slowly emerging as a viable sutured based inguinal hernia repair. We have conducted this review article to look at the various types of mesh based and sutured based repairs for open inguinal hernia repair including their complications and recurrence rate. We also looked at the effect of chronic pain and the role of antibiotic prophylaxis in open inguinal hernia repair.

Keywords- "mesh repair", "Open hernia repair", "Tension free repair", "sutured hernia repair", "chronic pain" and "antibiotic prophylaxis"

Introduction

Inguinal hernia repair is a common general surgical procedure that is performed. Open inguinal hernia repairs are still the most common hernia repair that is performed worldwide despite the introduction of laparoscopic repair. The initial open inguinal hernia repairs were done under tension with sutures to strengthen the posterior wall of the inguinal canal. The introduction of the Lichtenstein repair which incorporated the use of synthetic material like mesh which was sutured to posterior wall of the inguinal canal under no tension. This method has revolutionized the management of inguinal hernias, and it has become the most performed procedure in the world(1,2).

The open inguinal hernia repairs can be divided into tissue repair and mesh repair. Among the tissue repair, the Shouldice repair is the most repair that is performed, with the Bassini repair and Darning method being rarely performed. For the mesh repair, the Lichtenstein repair is the most common procedure that is performed with plug and patch method by Rudkow and Robbins and the Prolene hernia system being the other variants of the mesh repair(3). The surgical treatment of open inguinal hernia can also be divided into mesh and non-mesh based repair with the addition of the Desarda repair being latest tension free tissue based repair(4,5).

The advantage of performing open inguinal hernia repairs is that they can be performed under local or regional anesthesia, the learning curve for these procedures are short they are associated with very low complications. All open inguinal hernia procedures are also cost effective and are associated with reduced stay in the hospital, and they do not require any additional and costly operative material(6).

The European Hernia Society guidelines on the treatment of inguinal hernia in adults has recommended the Lichtenstein repair as the best open inguinal hernia surgery as it has a short learning curve, and it has a low recurrence rate of less than 2 %. For patients who opt out of performing a mesh repair, the Shouldice repair is the best non mesh open inguinal hernia operation that can be performed(7–9).

The HerniaSurge guidelines for the management of groin hernias have recommended that the mesh and non-mesh-based repairs are the best and most effective surgical approaches. The mesh-based approaches are associated with the least risk of recurrence. Shouldice repair is considered the best non mesh based inguinal hernia repair for patients who do not want a mesh or where a mesh is contraindicated. Shouldice repair is associated with the lowest recurrence among the non-mesh-based or tissue repairs. The Desarda technique though is associated with a shorter learning curve but is not recommended due to its limited data on recurrence and chronic pain(10).

As open inguinal hernia repairs are still a common surgical procedure that is performed by general surgeons, we have conducted this review article to investigate the common types of open hernia repair including the mesh and non-mesh-based repairs, the recurrence rates and chronic pain among these procedures and the role of antibiotic prophylaxis for open hernia repair. A literature review was made on PubMed, Google Scholar, Semantic Scholar, and Cochrane databases to look for original articles, observational studies, clinical trials, clinical reviews, review articles and meta-analysis from 1995 to 2024. The following keywords were used “mesh repair”, “open hernia repairs”, “tension free repair”, “sutured hernia repairs”, “chronic pain and” antibiotic prophylaxis”. All articles were in English language only and further article were obtained by manual cross checking. Case reports, commentaries and editorials were excluded. All articles with adults patients were included in this review. Pediatric patients and pregnant patients were excluded from this review.

Discussion

Mesh Based open inguinal hernia repairs

Lichtenstein repair

This is the most popular open mesh-based repair that was introduced by Irving Lichtenstein in 1984, and is also known as the tension free inguinal hernia repair. This procedure was originally performed under local anesthesia and after ligation of the hernia sac and identification of the ilioinguinal and iliohypogastric nerves, the posterior wall of the inguinal canal is reinforced with a synthetic mesh. The mesh is anchored with non-absorbable sutures to the inguinal ligament and conjoint tendon. This procedure is not done under tension, and it is associated with reduced morbidity and recurrence(11).The Lichtenstein repair has been retrospectively reviewed and the risk of surgical site infection was low, the incidence of seroma formation and scrotal hematoma were also low. The recurrence rate was around 1% for this type of inguinal hernia repair (12).The learning curve for performing this operation among surgical residents and junior surgeons is relatively short and 40 cases are usually sufficient before performing it independently(13).

Several technical modifications have been done for the Lichtenstein repair which include using a larger mesh size, using interrupted sutures to anchor the mesh to the aponeurosis of the internal oblique muscle and greater overlap of the mesh over the pubic symphysis. Further recommendations include identification and preservation of the ilioinguinal and iliohypogastric nerve, protecting the cremasteric fascia, management of the hernia sac, proper fixation of the mesh to the rectus abdominus sheath, and using a mesh size of 7.5cm by 15cm(14–16).

The identification of the ilioinguinal and iliohypogastric nerve during the hernia repair is important to reduce the risk of injury during dissection and fixation of the mesh. A systemic review and meta-analysis by Moseholm et al on-nerve identification during inguinal hernia repair concluded that the rate of identification of the ilioinguinal nerve was 82% and iliohypogastric nerve was 62%(17,18).

The mesh repair was compared against the non-mesh repair of inguinal hernias by Smith et al, and they concluded that mesh repair was associated with a reduced recurrence rate and the risk factors for recurrence include obesity, history of smoking, and direct hernias(19).Bisgaard et al and Butters et al followed up patients who underwent the Lichtenstein repair for 5 years and concluded that the recurrence rate was 0,when compared to those who underwent sutured hernia repair(20,21).

The Lichtenstein repair was compared to the Shouldice repair in a randomized trial by Danielsson et al, and the recurrence rate was significantly higher in the Shouldice group, and the number of sick leave taken was also higher in this group(22).A similar randomized control trial comparing the Lichtenstein repair and Shouldice repair by Ahmadinejad et al also concluded that the recurrence rate was lower in the Lichtenstein repair group(23).

The method of fixation of the mesh has been evaluated with sutured fixation being compared with glue fixation. There have been several systemic reviews and meta-analysis that have been conducted, with the use of fibrin or butyl-2-cyabiacylate being used as the glue to fix the mesh. These studies concluded that glue fixation is associated with reduced operative time and comparable post operative pain, chronic pain and length of hospital stay. However, the duration of follow up in all the studies were not consistent, hence further randomized trials will be needed

to evaluate the true recurrence rate and efficacy of glue fixation(24–28).A systemic review and meta-analysis comparing the use of self-gripping mesh against sutured mesh fixation was conducted by Sajid et al, and this study concluded that self -gripping mesh failed to demonstrate any advantage over sutured mesh fixation with the incidence of post operative pain, chronic pain and recurrence rates being the same(29).

The Plug and Patch and the Prolene Hernia System

The plug and patch repair involves the use of a mesh that is inserted in the pre-peritoneal space and anchored to the tissues with sutures followed by a flat mesh is then inserted anchored to the inguinal ligament and conjoint tendon. The operative time and post operative complications were reduced, and it was introduced as an alternative to the Lichtenstein repair(30–32).The Plug and Patch repair was compared to the Lichtenstein repair and the duration of operation, post operative complications and recurrence rate were comparable(33).A randomized control trial comparing the Plug and Patch repair with the Lichtenstein repair concluded that though the operative time was reduced in the Plug and Patch repair, there was no difference with regard to the post operative complication, chronic pain and recurrence rate(34).

The Prolene hernia system is a three-dimensional bilayer mesh that reinforces the posterior wall of the inguinal canal and pre-peritoneal space during an open inguinal hernia repair. Blunt dissection is done in the preperitoneal space, and it is inserted via the deep ring, and it requires minimal sutures to anchor the mesh(35).Retrospective evaluation of this procedure showed that the operative time was comparable to the other mesh repairs and most common complication was hematoma formation, wound infection and the recurrence rate was 1.6% (36).Prospective randomized control trial by Pierides et al comparing the Prolene hernia system with the Lichtenstein repair concluded that both procedures were associated with comparable post operative complications, chronic pain and recurrence rate(37).A meta-analysis by Decker et al comparing the Prolene hernia system versus the Lichtenstein repair. This study included 1377 hernia repairs, and they concluded that there was no difference with regards to recurrence rate and chronic pain(38).

A meta-analysis of randomized control trials of open mesh techniques for inguinal hernia repair was conducted by Zhao et al.2708 patients were included in this study and they concluded that the Lichtenstein, Plug and Patch and Prolene hernia System were associated with similar post operative complications, chronic pain and mid -term recurrence rates(39).A prospective randomized controlled trial comparing the three year outcome of the Prolene hernia system, Lichtenstein mesh and the Plug and Patch for primary inguinal hernia repair was conducted by

Dalenback et al. 472 patients had undergone hernia repair and they were follow-up to three years. This study concluded that there was no difference with regards to the post operative complications, recurrence rates and chronic pain(40).

Non-Mesh based Open Inguinal Hernia Repair

Shouldice Repair

Shouldice repair is the most common non-mesh based open inguinal hernia repair. The important components of this operation include resection of the cremaster muscle, division of the posterior wall of the inguinal canal, and reconstruction of the posterior wall that is conducted with stainless steel wires(41). Hay et al conducted a multi-center trial on 1578 patients who underwent the Shouldice repair and Bassini repair and the recurrence rates were 6.1% for the Shouldice repair and 8.6% for the Bassini repair(42). The recurrence rate of the Shouldice repair is around 4.7% to 10.1% with the number of operations being performed has decreased due to the introduction of the mesh based repairs(43). Certain centers have performed the Shouldice repair and followed up the patients after five years have obtained a recurrence rate of 2.88%(44).

A Cochrane review was conducted by Amato et al comparing Shouldice repair versus other open inguinal hernia techniques. A total of 2566 patients underwent Shouldice repair, 1121 mesh repair and 1608 non-mesh repair. The recurrence rate of the Shouldice repair was higher than the mesh repair but it was the lowest among the sutured repairs. This study concluded that the Shouldice repair was the best non-mesh hernia repair with reference to recurrence, but it requires a higher learning curve and operative time(45). Kockerling et al compared the Shouldice repair with the Lichtenstein and laparoscopic inguinal hernia repair and they concluded that in certain patients with small hernias the Shouldice repair is indicated due to its low chronic pain rate(46).

Table I

Study	Study type	Year	N=numbers	Lichtenstein repair recurrence rate	Shouldice repair recurrence rate

Danielsson et al	Randomized study	1999	178	0%	10.11%
Butters et al	Randomized study	2006	150	1.3%	10.12%

Table showing the recurrence rate between the Lichtenstein repair and the Shouldice repair

Desarda Repair

This inguinal hernia repair technique was introduced by Desarda where after excision of the hernia sac, an incision is made on the external oblique aponeurosis and a strip of the external oblique aponeurosis is excised and sutured to the posterior wall to reinforce it. This repair is under no tension, and it functions to strengthen the posterior wall. Desarda operated on 400 patients and there was one patient who developed recurrence(47). Several other studies were done on the Desarda repair, and the operative time and post operative morbidity and mortality were low. The recurrence rates were low, and the cost of the procedure was also low(48–50).

The Desarda technique was compared with the Lichtenstein repair in several studies and these studies concluded that there was no difference regarding post operative morbidity, mortality, length of hospital stays, recurrence rate and chronic pain(51–55). A systemic review and meta-analysis of randomized control trials comparing the Desarda technique versus the Lichtenstein repair in primary inguinal hernias. 2159 patients from 6 randomized control trials were included in the study. This study concluded that both procedures were associated with reduced complications and recurrence rates, with the Lichtenstein repair being associated with a slight increase in seroma formation(56). A systemic review by Ge et al also compares the Desarda technique and Lichtenstein repair for the treatment of primary inguinal hernias. 1014 patients were included in this study and this study also concluded that there were no differences with regard to post operative complication, recurrence rate, chronic pain and hospital stay(57). A similar systemic review and meta-analysis by Pereira et al comparing the Desarda technique with the Lichtenstein repair also came out with the same conclusions(58).

A randomized control trial comparing the Desarda technique versus the Lichtenstein repair was performed by Szopinski et al. 208 patients were randomized to 105 who underwent the Desarda repair and 103 the Lichtenstein repair. This study concluded that the incidence of chronic pain and recurrence rates were equal among both groups(59). A systemic review and meta-analysis was conducted by Ndong et al to look at the suitability of the Desarda repair in the emergency inguinal hernia repair. 199 patients were included in this study and the postoperative

complication, recurrence rates and seroma rates were similar, hence it has been suggested that the Desarda repair can be used in emergency inguinal hernia repair(60).

Bassini Repair and other open repairs

This inguinal hernia repair was introduced by Eduardo Bassini and it involves suturing the transversalis fascia and conjoint tendon to the inguinal ligament behind the spermatic cord and employing a Tanner slide to prevent tension. This procedure was popular before the introduction of the mesh-based repair and the major downside of this repair was that it was done under tension and the recurrence rates were around 6% to 8%. This repair is commonly done in countries where mesh is not available or is too costly(61). The Bassini repair was compared to other repair methods like the Lichtenstein repair, Darning Method and Shouldice repair and although there were no major post operative complications, the recurrence rate was high with the Bassini repair and hence it is rarely used(62–64).

The Darning technique involves the approximation of the conjoint tendon to the inguinal ligament with non-absorbable sutures thereby forming a weave in the posterior wall. This method is done in cases where a mesh repair cannot be performed, and it has a higher recurrence rate when compared to the mesh-based repairs(65,66). The McVay’s repair which involves the approximation of the transversalis fascia to the Cooper’s ligament, but this repair was under tension and associated with post operative pain and a high recurrence rate(67–69).

Table II

Study	Study Type	Year	N=numbers	Lichtenstein repair recurrence rate (%)	Desarda repair recurrence rate (%)
Emile et al	Systemic Review/Meta-analysis	2017	2159	0.98%	0.91%
Jain et al	Randomized control trial	2021	87	0	0
Mohamedahmed et al	Meta-analysis	2022	3177	0.9%	0.65%

Table comparing the recurrence rate of the Lichtenstein repair and the Desarda repair

Chronic Pain after inguinal hernia repair

This is defined as pain arising from the surgical site that persists for more than 3 months after the inguinal hernia repair. As the recurrence rates decreased after the introduction of the mesh -based repairs, chronic pain has become a problem. The risk factors for developing chronic pain include young patients, female sex and developing pain during the immediate post operative period. The cause of chronic pain is still unknown, but several theories include the inflammatory reaction

from the mesh, nerve entrapment, type of mesh and fixation of the mesh(70–72). A systemic review and Meta-analysis by Oberg et al comparing chronic pain after mesh versus non-mesh repair for inguinal hernia and this study concluded that there was no difference with regard to the type of hernia repair regarding chronic pain(73).The incidence of chronic pain is also not affected by prophylactic division of the ilioinguinal nerve and also by the type and characteristics of the mesh that is used(74–76).

Antibiotic prophylaxis for inguinal hernia repair

Inguinal hernia surgery is often considered a clean surgery and antibiotic prophylaxis is not indicated for low-risk patients, but it is indicated for high-risk patients. Antibiotic prophylaxis is also encouraged for centers with high rates of surgical site infection (77).Several systemic reviews and meta-analysis were conducted to look if antibiotic prophylaxis is need and these studies concluded that antibiotic prophylaxis is not indicated for inguinal hernia repair. However, the quality of the studies that were included were not good and proper randomized control trials should be done to establish if prophylactic antibiotics are needed(78,79).A Cochrane review on the role of antibiotic prophylaxis for the prevention of post operative infection was unable to conclude if antibiotic prophylaxis is indicated for inguinal hernia repair as the evidence that was collected were of low quality(80).

Conclusion

Open inguinal hernia repair has seen a change in trend with the introduction of the mesh-based repairs. The Lichtenstein repair is the most popular repair that is practiced worldwide. It is simple to perform, requires a short learning curve, can be done under local anesthesia and it is associated with the lowest recurrence rate among all the open inguinal hernia repairs. The other mesh-based repairs like the Plug and Patch and the Prolene hernia system are not as commonly used.

The Shouldice repair is the most popular sutured based repair, but it has a longer learning curve, and although it can be performed under local anesthesia, the recurrence rate is still higher when compared to the Lichtenstein repair. The Desarda technique is good tissue-based repair that can be easily learned and since it is a tension free procedure, it can be an alternative to the Lichtenstein repair. The only drawback of the Desarda technique is the long-term recurrence rate which has not been established yet.

Chronic pain now is an emerging post operative complication that occurs especially after the mesh-based repair, and there is no consensus on its management. The indication for prophylactic antibiotics is an area where the operating surgeon will decide if antibiotic prophylaxis is indicated or not. Open inguinal hernia repairs will continue to be one of the most common operations that are performed worldwide, and it will retain its place in the surgical treatment of inguinal hernias despite the introduction of laparoscopic inguinal hernia repair.

References

1. Awad SS, Fagan SP. Current approaches to inguinal hernia repair. *Am J Surg.* 2004 Dec;188(6A Suppl):9S-16S. doi: 10.1016/j.amjsurg.2004.09.007. PMID: 15610887.
2. Amid PK. Groin hernia repair: open techniques. *World J Surg.* 2005 Aug;29(8):1046-51. doi: 10.1007/s00268-005-7967-x. PMID: 15983714.
3. Antoniou SA, Pointner R, Grandrath FA. Current treatment concepts for groin hernia. *Langenbecks Arch Surg.* 2014 Jun;399(5):553-8. doi: 10.1007/s00423-014-1212-8. Epub 2014 May 14. PMID: 24824799.
4. Sapiyeva ST, Abatov NT, Aliyakparov MT, Badyrov RM, Yoshihiro N, Brizitskaya LV, Yesniyazov DK, Yukhnevich YA. Non-mesh inguinal hernia repair: Review. *Asian J Surg.* 2024 Jul 2:S1015-9584(24)01272-7. doi: 10.1016/j.asjsur.2024.06.055. Epub ahead of print. PMID: 38960759.
5. Faylona JM. Open anterior groin hernia repair. *Ann Laparosc Endosc Surg.* 2017 May 26;2:96–96. doi: 10.21037/ales.2017.05.06
6. Morrison, John. A case for open inguinal hernia repair. *International Journal of Abdominal Wall and Hernia Surgery* 1(3):p 69-73, Oct–Dec 2018. | DOI: 10.4103/ijawhs.ijawhs_17_18
7. Miserez M, Peeters E, Aufenacker T, Bouillot JL, Campanelli G, Conze J, Fortelny R, Heikkinen T, Jorgensen LN, Kukleta J, Morales-Conde S, Nordin P, Schumpelick V, Smedberg S, Smietanski M, Weber G, Simons MP. Update with level 1 studies of the European Hernia Society guidelines on the treatment of inguinal hernia in adult patients. *Hernia.* 2014 Apr;18(2):151-63. doi: 10.1007/s10029-014-1236-6. Epub 2014 Mar 20. Erratum in: *Hernia.* 2014 Jun;18(3):443-4. PMID: 24647885.
8. Simons MP, Aufenacker T, Bay-Nielsen M, Bouillot JL, Campanelli G, Conze J, de Lange D, Fortelny R, Heikkinen T, Kingsnorth A, Kukleta J, Morales-Conde S, Nordin P, Schumpelick V, Smedberg S, Smietanski M, Weber G, Miserez M. European Hernia

- Society guidelines on the treatment of inguinal hernia in adult patients. *Hernia*. 2009 Aug;13(4):343-403. doi: 10.1007/s10029-009-0529-7. Epub 2009 Jul 28. PMID: 19636493; PMCID: PMC2719730.
9. Köckerling F, Schug-Pass C. Tailored approach in inguinal hernia repair - decision tree based on the guidelines. *Front Surg*. 2014 Jun 20;1:20. doi: 10.3389/fsurg.2014.00020. PMID: 25593944; PMCID: PMC4286983.
 10. Stabilini C, van Veenendaal N, Aasvang E, Agresta F, Aufenacker T, Berrevoet F, Burgmans I, Chen D, de Beaux A, East B, Garcia-Alamino J, Henriksen N, Köckerling F, Kukleta J, Loos M, Lopez-Cano M, Lorenz R, Miserez M, Montgomery A, Morales-Conde S, Oppong C, Pawlak M, Podda M, Reinpold W, Sanders D, Sartori A, Tran HM, Verdaguer M, Wiessner R, Yeboah M, Zwaans W, Simons M. Update of the international HerniaSurge guidelines for groin hernia management. *BJS Open*. 2023 Sep 5;7(5):zrad080. doi: 10.1093/bjsopen/zrad080. Erratum in: *BJS Open*. 2024 Mar 1;8(2):zrae034. doi: 10.1093/bjsopen/zrae034. PMID: 37862616; PMCID: PMC10588975.
 11. Amid, P.K., Shulman, A.G. & Lichtenstein, I.L. The Lichtenstein open "tension-free" mesh repair of inguinal Hernias. *Surg Today* **25**, 619–625 (1995). <https://doi.org/10.1007/BF00311436>
 12. Sakorafas GH, Halikias I, Nissotakis C, Kotsifopoulos N, Stavrou A, Antonopoulos C, Kassaras GA. Open tension free repair of inguinal hernias; the Lichtenstein technique. *BMC Surg*. 2001;1:3. doi: 10.1186/1471-2482-1-3. Epub 2001 Oct 15. PMID: 11696246; PMCID: PMC59657.
 13. Merola G, Cavallaro G, Iorio O, Frascio M, Pontecorvi E, Corcione F, Andreuccetti J, Pignata G, Stabilini C, Bracale U. Learning curve in open inguinal hernia repair: a quality improvement multicentre study about Lichtenstein technique. *Hernia*. 2020 Jun;24(3):651-659. doi: 10.1007/s10029-019-02064-x. Epub 2019 Nov 22. PMID: 31758277.
 14. Messias BA, Nicastro RG, Mocchetti ER, Waisberg J, Roll S, Junior MAFR. Lichtenstein technique for inguinal hernia repair: ten recommendations to optimize surgical outcomes. *Hernia*. 2024 Aug;28(4):1467-1476. doi: 10.1007/s10029-024-03094-w. Epub 2024 Jun 20. PMID: 38900355; PMCID: PMC11297121.
 15. Messias BA, Almeida PL, Ichinose TMS, Mocchetti ER, Barbosa CA, Waisberg J, Roll S, Ribeiro Junior MF. The Lichtenstein technique is being used adequately in inguinal hernia

repair: national analysis and review of the surgical technique. *Rev Col Bras Cir.* 2023 Dec 8;50:e20233655. doi: 10.1590/0100-6991e-20233655-en. PMID: 38088634; PMCID: PMC10668585.

16. Kulacoglu, Hakan. Some more time with an old friend: Small details for better outcomes with Lichtenstein repair for inguinal hernias. *International Journal of Abdominal Wall and Hernia Surgery* 5(4):p 221-228, Oct–Dec 2022. | DOI: 10.4103/ijawhs.ijawhs_40_22
17. Moseholm VB, Baker JJ, Rosenberg J. Nerve identification during open inguinal hernia repair: a systematic review and meta-analyses. *Langenbecks Arch Surg.* 2023 Oct 24;408(1):417. doi: 10.1007/s00423-023-03154-2. Erratum in: *Langenbecks Arch Surg.* 2023 Nov 18;408(1):439. doi: 10.1007/s00423-023-03180-0. PMID: 37874414; PMCID: PMC10598160.
18. Moseholm VB, Baker JJ, Rosenberg J. Identification of the ilioinguinal and iliohypogastric nerves during open inguinal hernia repair: a nationwide register-based study. *Hernia.* 2024 Aug;28(4):1181-1186. doi: 10.1007/s10029-024-03002-2. Epub 2024 Mar 19. PMID: 38502369; PMCID: PMC11297051.
19. Smith SM, Khoja AA, Jacobsen JHW, Kovoov JG, Tivey DR, Babidge WJ, Chandraratna HS, Fletcher DR, Hensman C, Karatassas A, Loi KW, McKertich KMF, Yin JMA, Maddern GJ. Mesh versus non-mesh repair of groin hernias: a rapid review. *ANZ J Surg.* 2022 Oct;92(10):2492-2499. doi: 10.1111/ans.17721. Epub 2022 Apr 21. PMID: 35451174; PMCID: PMC9790697.
20. Bisgaard T, Bay-Nielsen M, Christensen IJ, Kehlet H. Risk of recurrence 5 years or more after primary Lichtenstein mesh and sutured inguinal hernia repair. *Br J Surg.* 2007 Aug;94(8):1038-40. doi: 10.1002/bjs.5756. PMID: 17607708.
21. Butters M, Redecke J, Königer J. Long-term results of a randomized clinical trial of Shouldice, Lichtenstein and transabdominal preperitoneal hernia repairs. *Br J Surg.* 2007 May;94(5):562-5. doi: 10.1002/bjs.5733. PMID: 17443855.
22. Danielsson P, Isacson S, Hansen MV. Randomised study of Lichtenstein compared with Shouldice inguinal hernia repair by surgeons in training. *Eur J Surg.* 1999 Jan;165(1):49-53. doi: 10.1080/110241599750007504. PMID: 10069634.

23. Ahmadinejad I, Jalali A, Ahmadinejad M, Soltanian A, Ahamdinejad Y, Shirzadi A, Chaghamirzayi P. Inguinal hernia: Lichtenstein VS Shouldice technique repair: A randomized controlled trial. *Surg Open Sci.* 2024 Jan 15;17:70-74. doi: 10.1016/j.sopen.2024.01.001. PMID: 38298435; PMCID: PMC10828570.
24. Ladwa N, Sajid MS, Sains P, Baig MK. Suture mesh fixation versus glue mesh fixation in open inguinal hernia repair: a systematic review and meta-analysis. *Int J Surg.* 2013;11(2):128-35. doi: 10.1016/j.ijisu.2012.12.013. Epub 2012 Dec 25. PMID: 23270616.
25. Liu H, Zheng X, Gu Y, Guo S. A meta-analysis examining the use of fibrin glue mesh fixation versus suture mesh fixation in open inguinal hernia repair. *Dig Surg.* 2014;31(6):444-51. doi: 10.1159/000370249. Epub 2015 Jan 14. PMID: 25592242.
26. Sun P, Cheng X, Deng S, Hu Q, Sun Y, Zheng Q. Mesh fixation with glue versus suture for chronic pain and recurrence in Lichtenstein inguinal hernioplasty. *Cochrane Database Syst Rev.* 2017 Feb 7;2(2):CD010814. doi: 10.1002/14651858.CD010814.pub2. PMID: 28170080; PMCID: PMC6464532.
27. Lin H, Zhuang Z, Ma T, Sun X, Huang X, Li Y. A meta-analysis of randomized control trials assessing mesh fixation with glue versus suture in Lichtenstein inguinal hernia repair. *Medicine (Baltimore).* 2018 Apr;97(14):e0227. doi: 10.1097/MD.00000000000010227. PMID: 29620633; PMCID: PMC5902270.
28. Trisca R, Oprea V, Toma M, Bucuri CE, Stancu B, Grad O, Gherman C. The Effectiveness of Cyanoacrylates versus Sutures for Mesh Fixation after Lichtenstein Repair (SCyMeLi STUDY) A Systematic Review and Meta-Analyze of Randomized Controlled Trials. *Chirurgia (Bucur).* 2024 Feb;119(1):87-101. doi: 10.21614/chirurgia.2024.v.119.i.1.p.87. PMID: 38465719.
29. Sajid MS, Farag S, Singh KK, Miles WF. Systematic review and meta-analysis of published randomized controlled trials comparing the role of self-gripping mesh against suture mesh fixation in patients undergoing open inguinal hernia repair. *Updates Surg.* 2014 Sep;66(3):189-96. doi: 10.1007/s13304-013-0237-9. Epub 2013 Oct 22. PMID: 24146297.
30. Sven Bringman, Stig Ramel, Björn Nyberg, Bo Anderberg, Introduction of herniorraphy with mesh plug and patch, *European Journal of Surgery*, Volume 166, Issue 4, May 2000, Pages 310–312, <https://doi.org/10.1080/110241500750009159>

31. Rutkow IM. The PerFix plug repair for groin hernias. *Surg Clin North Am.* 2003 Oct;83(5):1079-98, vi. doi: 10.1016/S0039-6109(03)00125-7. Erratum in: *Surg Clin North Am.* 2003 Dec;83(6):xiii. PMID: 14533905.
32. Zieren J, Hokschi B, Wenger FA, Opitz I, Müller JM. Inguinal hernia repair in the new millennium: plug and patch repair with local anesthesia. *World J Surg.* 2001 Feb;25(2):138-41. doi: 10.1007/s002680020093. PMID: 11338012.
33. Singh R, Gupta A, Shah A, Singh A. A study about inguinal hernia mesh repairs: plug and patch versus lichtenstein mesh repair technique. *International Surgery Journal.* 2016;1967-74. DOI: <https://doi.org/10.18203/2349-2902.isj20163562>
34. Kingsnorth AN, Porter CS, Bennett DH, Walker AJ, Hyland ME, Sodergren S. Lichtenstein patch or Perfix plug-and-patch in inguinal hernia: a prospective double-blind randomized controlled trial of short-term outcome. *Surgery.* 2000 Mar;127(3):276-83. doi: 10.1067/msy.2000.104124. PMID: 10715982.
35. Gilbert, A.I., Graham, M.F. & Voigt, W.J. A bilayer patch device for inguinal hernia repair. *Hernia* 3, 161-166 (1999). <https://doi.org/10.1007/BF01195319>
36. Berende CA, Ruurda JP, Hazenberg CE, Olsman JG, van Geffen HJ. Inguinal hernia treatment with the Prolene Hernia System in a Dutch regional training hospital. *Hernia.* 2007 Aug;11(4):303-6. doi: 10.1007/s10029-007-0218-3. Epub 2007 Apr 4. PMID: 17406785.
37. Pierides G, Vironen J. A prospective randomized clinical trial comparing the Prolene Hernia System® and the Lichtenstein patch technique for inguinal hernia repair in long term: 2- and 5-Year results. *Am J Surg.* 2011 Aug;202(2):188-93. doi: 10.1016/j.amjsurg.2010.06.027. PMID: 21810499.
38. Decker E, Currie A, Baig MK. Prolene hernia system versus Lichtenstein repair for inguinal hernia: a meta-analysis. *Hernia.* 2019 Jun;23(3):541-546. doi: 10.1007/s10029-019-01897-w. Epub 2019 Feb 15. PMID: 30771031.

39. Zhao G, Gao P, Ma B, Tian J, Yang K. Open mesh techniques for inguinal hernia repair: a meta-analysis of randomized controlled trials. *Ann Surg.* 2009 Jul;250(1):35-42. doi: 10.1097/SLA.0b013e3181ad63cc. PMID: 19561484.
40. Dalenbäck J, Andersson C, Anesten B, Björck S, Eklund S, Magnusson O, Rimbäck G, Stenquist B, Wedel N. Prolene Hernia System, Lichtenstein mesh and plug-and-patch for primary inguinal hernia repair: 3-year outcome of a prospective randomised controlled trial. The BOOP study: bi-layer and connector, on-lay, and on-lay with plug for inguinal hernia repair. *Hernia.* 2009 Apr;13(2):121-9; discussion 231. doi: 10.1007/s10029-008-0443-4. Epub 2008 Nov 13. PMID: 19015933.
41. Bendavid R. The Shouldice technique: a canon in hernia repair. *Can J Surg.* 1997 Jun;40(3):199-205, 207. PMID: 9194781; PMCID: PMC3952996.
42. Hay JM, Boudet MJ, Fingerhut A, Poucher J, Hennes H, Habib E, Veyrières M, Flamant Y. Shouldice inguinal hernia repair in the male adult: the gold standard? A multicenter controlled trial in 1578 patients. *Ann Surg.* 1995 Dec;222(6):719-27. doi: 10.1097/00000658-199512000-00005. PMID: 8526578; PMCID: PMC1235020.
43. Lorenz R, Arlt G, Conze J, Fortelny R, Gorjanc J, Koch A, Morrison J, Oprea V, Campanelli G. Shouldice standard 2020: review of the current literature and results of an international consensus meeting. *Hernia.* 2021 Oct;25(5):1199-1207. doi: 10.1007/s10029-020-02365-6. Epub 2021 Jan 27. PMID: 33502639.
44. Martín Duce A, Lozano O, Galván M, Muriel A, Villeta S, Gómez J. Results of Shouldice hernia repair after 18 years of follow-up in all the patients. *Hernia.* 2021 Oct;25(5):1215-1222. doi: 10.1007/s10029-021-02422-8. Epub 2021 May 19. PMID: 34009507.
45. Amato B, Moja L, Panico S, Persico G, Rispoli C, Rocco N, Moschetti I. Shouldice technique versus other open techniques for inguinal hernia repair. *Cochrane Database Syst Rev.* 2012 Apr 18;2012(4):CD001543. doi: 10.1002/14651858.CD001543.pub4. PMID: 22513902; PMCID: PMC6465190.
46. Köckerling F, Koch A, Adolf D, Keller T, Lorenz R, Fortelny RH, Schug-Pass C. Has Shouldice Repair in a Selected Group of Patients with Inguinal Hernia Comparable Results to Lichtenstein, TEP and TAPP Techniques? *World J Surg.* 2018 Jul;42(7):2001-2010. doi: 10.1007/s00268-017-4433-5. PMID: 29299648; PMCID: PMC5990577.

47. Desarda MP. INTRODUCTION NEW METHOD OF INGUINAL HERNIA REPAIR: A NEW SOLUTION. Vol. 71, ANZ J. Surg. 2001. <https://doi.org/10.1046/j.1440-1622.2001.02092.x>
48. Bashir SH, Afzal MO, Rafi YA. Desarda technique for inguinal hernia repair, a multicenter experience. Pak J Med Health Sci. 2015 Jan 1;9(1):311-.
49. Gurgenidze M, Datuashvili G. DESARDA TECHNIQUE FOR INGUINAL HERNIA REPAIR. Georgian Med News. 2018 Jul-Aug;(280-281):7-10. PMID: 30204086.
50. Khairy, Mustafa; Madbouly, Abd El-Wahab; and Sharaf, Mohammed (2020) "Evaluation of Desarda Technique in Inguinal Herniorrhaphy," *Al-Azhar International Medical Journal*: Vol. 1: Iss. 2, Article 7.
DOI: <https://doi.org/10.21608/aimj.2020.23116.1116>
51. Moghe D, Prajapati R, Banker A, Khajanchi M. A Comparative Study of Desarda's Versus Lichtenstein's Technique for Uncomplicated Inguinal Hernia Repair. Cureus. 2022 Apr 9;14(4):e23998. doi: 10.7759/cureus.23998. PMID: 35547436; PMCID: PMC9086529.
52. Ali A, Bukhari SUS, Awan SA, Ahmed U, Ahmed A, Babar MW. Comparison between Desarda's Inguinal Hernia Repair and Lichtenstein Hernioplasty in terms of Complications, Operative time and Cost-effectiveness. Pak Armed Forces Med J [Internet]. 2022 Sep. 6 [cited 2024 Aug. 22];72(4):1339-42. Available from: <https://www.pafmj.org/PAFMJ/article/view/8016>
53. Gedam BS, Bansod PY, Kale VB, Shah Y, Akhtar M. A comparative study of Desarda's technique with Lichtenstein mesh repair in treatment of inguinal hernia: A prospective cohort study. Int J Surg. 2017 Mar;39:150-155. doi: 10.1016/j.ijssu.2017.01.083. Epub 2017 Jan 25. PMID: 28131917.
54. Philipp M, Leuchter M, Lorenz R, Grambow E, Schafmayer C, Wiessner R. Quality of Life after Desarda Technique for Inguinal Hernia Repair-A Comparative Retrospective Multicenter Study of 120 Patients. J Clin Med. 2023 Jan 28;12(3):1001. doi: 10.3390/jcm12031001. PMID: 36769652; PMCID: PMC9917682.
55. Zulu HG, Mewa Kinoo S, Singh B. Comparison of Lichtenstein inguinal hernia repair with the tension-free Desarda technique: a clinical audit and review of the literature. Trop

Doct. 2016 Jul;46(3):125-9. doi: 10.1177/0049475516655070. Epub 2016 Jun 16. PMID: 27317612.

56. Emile SH, Elfeki H. Desarda's technique versus Lichtenstein technique for the treatment of primary inguinal hernia: a systematic review and meta-analysis of randomized controlled trials. *Hernia*. 2018 Jun;22(3):385-395. doi: 10.1007/s10029-017-1666-z. Epub 2017 Sep 9. PMID: 28889330.
57. Ge H, Liang C, Xu Y, Ren S, Wu J. Desarda versus Lichtenstein technique for the treatment of primary inguinal hernia: A systematic review. *Int J Surg*. 2018 Feb;50:22-27. doi: 10.1016/j.ijssu.2017.11.055. Epub 2017 Dec 23. PMID: 29277678.
58. Pereira C, Varghese B. Desarda Non-mesh Technique Versus Lichtenstein Technique for the Treatment of Primary Inguinal Hernias: A Systematic Review and Meta-Analysis. *Cureus*. 2022 Nov 18;14(11):e31630. doi: 10.7759/cureus.31630. PMID: 36540427; PMCID: PMC9759756.
59. Szopinski J, Dabrowiecki S, Pierscinski S, Jackowski M, Jaworski M, Szuflet Z. Desarda versus Lichtenstein technique for primary inguinal hernia treatment: 3-year results of a randomized clinical trial. *World J Surg*. 2012 May;36(5):984-992. doi: 10.1007/s00268-012-1508-1. PMID: 22392354; PMCID: PMC3321139.
60. Ndong A, Tendeng JN, Diallo AC, Diao ML, Diop S, Dia DA, Ma Nyemb PM, Konaté I. Is Desarda technique suitable to emergency inguinal hernia surgery? A systematic review and meta-analysis. *Ann Med Surg (Lond)*. 2020 Dec 2;60:664-668. doi: 10.1016/j.amsu.2020.11.086. PMID: 33312559; PMCID: PMC7721661.
61. Tse W, Johns W, Maher J, Rivers J, Miller T. Bassini inguinal hernia repair: Obsolete or still a viable surgical option? A single center cohort study. *International Journal of Surgery Open*. 2021 Oct 1;36. <https://doi.org/10.1016/j.ijso.2021.100415>
62. N N, R S. A Comparative Study between Modified Bassini's Repair and Lichtenstein Mesh Repair (LMR) of Inguinal Hernias in Rural Population. *J Clin Diagn Res*. 2014 Feb;8(2):88-91. doi: 10.7860/JCDR/2014/7431.4016. Epub 2014 Feb 3. PMID: 24701491; PMCID: PMC3972608.

63. Elsebae MM, Nasr M, Said M. Tension-free repair versus Bassini technique for strangulated inguinal hernia: A controlled randomized study. *Int J Surg*. 2008 Aug;6(4):302-5. doi: 10.1016/j.ijssu.2008.04.006. Epub 2008 May 2. PMID: 18573702.
64. Horharin P, Wilasrusmee C, Cherudchayaporn K, Pinyaku N, Phanpradi O, Phromsopha N. Comparative study of tailor-made mesh plug herniorrhaphy versus Lichtenstein herniorrhaphy versus Bassini operation: a prospective clinical trial. *Asian J Surg*. 2006 Apr;29(2):74-8. doi: 10.1016/S1015-9584(09)60111-1. PMID: 16644506.
65. Essawy A, Ibrahim M, Ashraf Mohamed Thabet E, Erfan M, Fathi Ismail Mohammed I. OUTCOME OF DARNING METHOD OF INGUINAL HERNIA REPAIR. (Print)Online) *Fayoum University Medical Journal Ismail et al.* 2019(1):15–23. <http://dx.doi.org/10.21608/fumj.2019.60370>
66. Olasehinde OO, Adisa AO, Agbakwuru EA, Etonyeaku AC, Kolawole OA, Mosanya AO. A 5-year Review of Darning Technique of Inguinal Hernia Repair. *Niger J Surg*. 2015 Jan-Jun;21(1):52-5. doi: 10.4103/1117-6806.152722. PMID: 25838768; PMCID: PMC4382644.
67. Banks SB, Cotlar AM. Classic groin hernia repair...lest we forget. *Curr Surg*. 2005 Mar-Apr;62(2):249-52. doi: 10.1016/j.cursur.2004.08.018. PMID: 15796951.
68. Ryan, J.J. (2001). The McVay Operation. In: Bendavid, R., Abrahamson, J., Arregui, M.E., Flament, J.B., Phillips, E.H. (eds) *Abdominal Wall Hernias*. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-8574-3_52
69. Junge K. Lotheissen/McVay Repair [Internet]. 2019. Available from: <https://www.ebsco.com/terms-of-use>
70. Nikkolo C, Lepner U. Chronic pain after open inguinal hernia repair. *Postgrad Med*. 2016 Jan;128(1):69-75. doi: 10.1080/00325481.2016.1121090. Epub 2015 Dec 4. PMID: 26567717.
71. Reinpold W. Risk factors of chronic pain after inguinal hernia repair: a systematic review. *Innov Surg Sci*. 2017 May 12;2(2):61-68. doi: 10.1515/iss-2017-0017. PMID: 31579738; PMCID: PMC6754000.

72. Pierides GA, Paajanen HE, Vironen JH. Factors predicting chronic pain after open mesh based inguinal hernia repair: A prospective cohort study. *Int J Surg*. 2016 May;29:165-70. doi: 10.1016/j.ijsu.2016.03.061. Epub 2016 Apr 4. PMID: 27058113.
73. Öberg S, Andresen K, Klausen TW, Rosenberg J. Chronic pain after mesh versus nonmesh repair of inguinal hernias: A systematic review and a network meta-analysis of randomized controlled trials. *Surgery*. 2018 May;163(5):1151-1159. doi: 10.1016/j.surg.2017.12.017. Epub 2018 Mar 13. PMID: 29506882.
74. Charalambous MP, Charalambous CP. Incidence of chronic groin pain following open mesh inguinal hernia repair, and effect of elective division of the ilioinguinal nerve: meta-analysis of randomized controlled trials. *Hernia*. 2018 Jun;22(3):401-409. doi: 10.1007/s10029-018-1753-9. Epub 2018 Mar 17. PMID: 29550948.
75. Rutegård M, Lindqvist M, Svensson J, Nordin P, Haapamäki MM. Chronic pain after open inguinal hernia repair: expertise-based randomized clinical trial of heavyweight or lightweight mesh. *Br J Surg*. 2021 Mar 12;108(2):138-144. doi: 10.1093/bjs/znaa049. PMID: 33711123; PMCID: PMC10364858.
76. Rutegård M, Gümüşçü R, Stylianidis G, Nordin P, Nilsson E, Haapamäki MM. Chronic pain, discomfort, quality of life and impact on sex life after open inguinal hernia mesh repair: an expertise-based randomized clinical trial comparing lightweight and heavyweight mesh. *Hernia*. 2018 Jun;22(3):411-418. doi: 10.1007/s10029-018-1734-z. Epub 2018 Jan 20. PMID: 29353339; PMCID: PMC5960495.
77. Zamkowski MT, Makarewicz W, Ropel J, Bobowicz M, Kałol M, Śmietański M. Antibiotic prophylaxis in open inguinal hernia repair: a literature review and summary of current knowledge. *Wideochir Inne Tech Maloinwazyjne*. 2016;11(3):127-136. doi: 10.5114/wiitm.2016.62800. Epub 2016 Oct 5. PMID: 27829934; PMCID: PMC5095278.
78. Al Riyees L, Al Madani W, Firwana N, Balkhy HH, Ferwana M, Alkudhayri A. Antibiotic Prophylaxis against Surgical Site Infection after Open Hernia Surgery: A Systematic Review and Meta-Analysis. *Eur Surg Res*. 2021;62(3):121-133. doi: 10.1159/000517404. Epub 2021 Aug 17. PMID: 34404046.
79. Erdas E, Medas F, Pisano G, Nicolosi A, Calò PG. Antibiotic prophylaxis for open mesh repair of groin hernia: systematic review and meta-analysis. *Hernia*. 2016 Dec;20(6):765-776. doi: 10.1007/s10029-016-1536-0. Epub 2016 Sep 3. PMID: 27591996.

80. Orelia CC, van Hessen C, Sanchez-Manuel FJ, Aufenacker TJ, Scholten RJ. Antibiotic prophylaxis for prevention of postoperative wound infection in adults undergoing open elective inguinal or femoral hernia repair. *Cochrane Database Syst Rev.* 2020 Apr 21;4(4):CD003769. doi: 10.1002/14651858.CD003769.pub5. PMID: 32315460; PMCID: PMC7173733.

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