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Nerve identification in open inguinal hernioplasty: A meta-analysis

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ABSTRACT

Objective: In open inguinal hernioplasty, three inguinal nerves are encountered in the surgical field. It is advisable to identify these nerves as careful dissection reduces the chances of debilitating post-operative inguinodynia. Recognizing nerves during surgery can be challenging. Limited surgical studies have reported on the identification rates of all nerves. This study aimed to calculate the pooled prevalence of each nerve from these studies.

Material and Methods: We searched PubMed, CENTRAL, CINAHL, ClinicalTrials.gov and Research Square. We selected articles that reported on the prevalence of all three nerves during surgery. A meta-analysis was performed on the data from eight studies. IVhet model from the software MetaXL was used for preparing the forest plot. Subgroup analysis was performed to understand the cause of heterogeneity.

Results: The pooled prevalence rates for Ilioinguinal nerve (IIN), Iliohypogastric nerve (IHN), and genital branch of genitofemoral nerve (GB) were 84% (95% CI 67-97%), 71% (95% CI 51-89%) and 53% (95% CI 31-74%), respectively. On subgroup analysis, the identification rates were higher in single centre studies and studies with a single primary objective as nerve identification. The heterogeneity was significant in all pooled values, excluding the subgroup analysis of IHN identification rates in single-centre studies.

Conclusion: The pooled values indicate low identification rates for IHN and GB. Significant heterogeneity and large confidence intervals reduce the importance of these values as quality standards. Better results are observed in single-centre studies and studies which are focused on nerve identification.

Keywords: Hernioplasty, inguinal hernia, peripheral nerves

INTRODUCTION

Chronic inguinal pain is a known complication of groin hernia surgery. Mild to moderate inguinodynia is common, but some patients may experience severe pain (1). The etiology of pain is poorly understood, and injury to inguinal nerves may contribute to it (2,3). There is a need for meticulous dissection and identification of all inguinal nerves during surgery, which was first stressed by Amid 2004 from the Lichtenstein Institute (4). Subsequently, it was also endorsed by the European Hernia Society guidelines on the treatment of inguinal hernia and the international guidelines for groin hernia management (5,6).

Recognizing nerves during surgery can be challenging. Their numbers and positions vary, and one of the nerves (the genital branch of the genitofemoral nerve) is thin and inconspicuous. Studies have reported wide variations in nerve identification rates, making compliance with recommendations difficult. We need to calculate the pooled estimates from the available literature and search for the causes of variations, which will, in turn, increase our understanding of traditional hernioplasty surgery.

MATERIAL and METHODS

The study followed PRISMA-P (Preferred Reporting Items for Systematic reviews and Meta-Analysis) guidelines (7,8).

Aim of the Study

The aim of the study was to calculate the pooled prevalence of nerve identification in open hernioplasty surgery and evaluate the effect of the study methodology on it. We also wanted to study the course of the nerves.

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Search Strategy

We searched the electronic database of PubMed/Medline, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Central Register of Controlled Trials (CENTRAL), ClinicalTrials.gov and Research Square in March 2022. The database of PubMed was searched with the following search strategies: Hernia, inguinal [Mesh] and peripheral nerves [Mesh], inguinal hernia [tiab] and nerves [tiab] and Lichtenstein repair [tiab]. We searched the database of CINAHL (EBSCO) with the following search strategy: inguinal hernia repair and inguinal nerves, keeping the search field optional. We searched the CENTRAL database with the terms inguinal hernia and inguinal nerves in the "title abstract keyword". We manually searched the references list of some of the review articles with the help of google scholar.

Inclusion and Exclusion Criteria

The articles on open inguinal hernia surgery that reported on all three inguinal nerves were included in the study. Prospective studies of all types (prospective comparative cohort, prospective non-comparative cohort and randomized controlled trials) were included. We excluded articles in which a report on any of the three inguinal nerves was missing.

Retrospective studies, case reports, editorials, conference proceedings and reviews were excluded. We excluded articles on ultrasound-guided nerve blocks or plane identification as they added bias to the objectives. The studies on cadavers, pediatric patients, and laparoscopic hernia surgeries were also excluded. The duplicates from the electronic search were removed manually.

Selection of Studies and Data Extraction

Based on inclusion and exclusion criteria, two authors, AB and PRT, independently identified the articles as included, excluded and uncertain. For uncertain articles, the full text was obtained and then reviewed. The consensus on included articles was reached through the involvement of author MKS.

Following Cochrane guidelines, a standard data collection sheet was prepared. The authors AB and MKS went through all the selected articles and collected data on the author, publication year, country, study type, sample size, objectives, methodology and results. The consensus was reached for any discrepancy in data by involving the author PRT.

Quality Assessment of the Included Studies

The included studies were separated into different types. Quality assessment of the randomized controlled trial was performed with software review Manager 5.4 (9). We assessed comparative cohort studies with the Newcastle Ottawa scale (NOS) and cohort studies without a comparison arm with JBI critical appraisal checklist for the case series (10,11). The authors AB and PRT independently performed quality assessment. The involvement of author MKS resolved any disputes.

Data Analysis

Data on nerve identification rates were extracted from the included studies. Binomial pooled prevalence was calculated, and forest plots were constructed using the Meta XL software. Statistical heterogeneity was measured with Cochrane's Q and I^2 statistics. The significance of heterogeneity was measured with the p-value. The funnel plots and the DOI plots were examined for asymmetry. We conducted a leave-one-out sensitivity analysis to understand the cause of heterogeneity. Subgroup analysis was conducted for objectives (single primary and multiple primaries) and the number of study centers (multi-centric and single center). An unweighted multiple regression analysis was conducted to identify the degree to which sample size, objectives and number of study centers were associated with nerve identification rates. SPSS 26.0 was used for regression analysis. The description of the course of the nerves was according to the source article.

RESULTS

The Outcome of Electronic Search

The PRISMA flow diagram of the study selection process is given in Figure 1. The initial search yielded 1214 articles, out of which 578 were duplicates, and 401 were ineligible for inclusion from titles/abstracts. The remaining 35 articles were searched for full text, and 32 articles were retrieved. Based on inclusion and exclusion criteria, the articles were further analyzed. After a careful review, only eight articles were selected for quantitative synthesis and systematic review (12-14).

Characteristics of the Included Studies

Characteristics of the included studies are presented in Table 1. The studies belonged to the period from 2006 to 2020. Two studies were from Brazil, and the remaining six were from Europe. The sample range was 29 to 973, with a median of 144. A total of 2118 surgical dissections were reported on nerve identification (15-22). The objectives of Lange 2009, Grossi 2015 and Mendes 2016 were centered on the intraoperative identification of the nerves only. There was more than one primary objective in other studies. The studies of Alfieri 2006, Lange 2009 and Sanders 2014 were multi-centric. Lange 2009 also studied the course of the nerves.

Qualitative Analysis of the Included Studies

Three comparative cohort studies, one randomized controlled trial and four non-comparative cohort studies were evaluated for quality. The result is presented in Table 2. All of the included studies were of good to excellent quality.

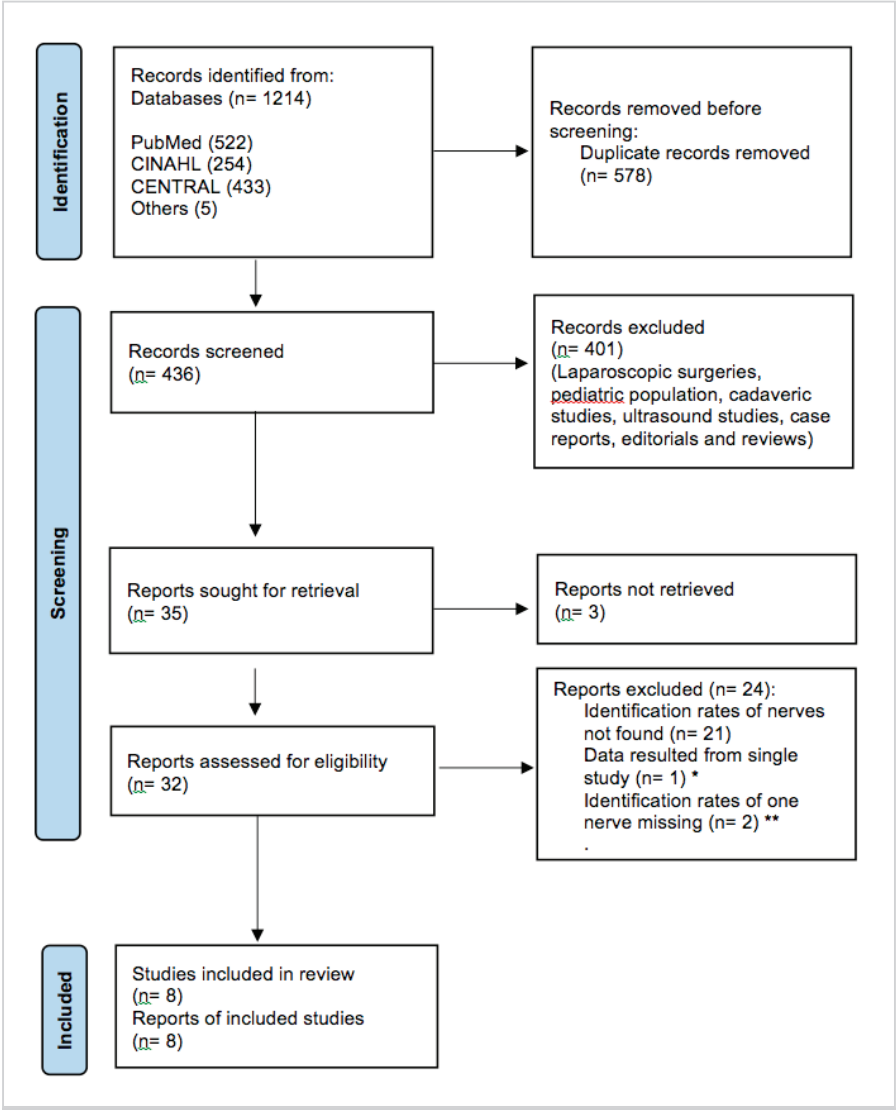


Figure 1. Flow diagram of the selection process of the studies.

*The studies of Smeds 2014 and Sanders 2014 were the result of a single trial. To avoid duplication of data we excluded the study of Smeds 2014. Smeds 2014 (12) also reported the results on a smaller sample size.

**The studies of Al-Dabbagh 2002 (13) and Emeksiz 2016 (14) were excluded as they reported identification and course of IIN and IHN only.

Meta-Analysis of Nerve Identification Rates

Ilioinguinal Nerve (IIN)

The forest plot of binomial pooled prevalence was constructed using the IVhet model (fixed effect, heterogeneity), as shown in Figure 2. In prevalence analysis, the IVhet model is preferred over the random effect model when the heterogeneity is significant, as seen in our study. It gives a more reliable coverage probability and exhibits lesser variance (23,24). We avoided the quality effect model as the methodology of included studies was heterogeneous (Table 2). The pooled prevalence rate of IIN was 84% (95% CI 67-97%). Statistical heterogeneity was significant (Cochrane's Q 228.21, I^2 97%, p< 0.001). On leave one out sensitivity analysis, the pooled prevalence varied from 81% to 91%. We analyzed the studies' funnel and DOI plots. We detected major asymmetry in these (Figure 3). An unweighted multiple regression analysis was performed with IIN identification rate as a dependent variable and sample size, centers of study and objectives as independent variables. We found that none of the independent variables significantly affected the outcome [model summary: R^2= 0.50, p= 0.37; coefficient: sample size (β= -0.19, p= 0.77), center (β= -0.59, p= 0.31), objective (β= 0.16, p= 0.75)].

Table 1. Characteristics of the included studies

Author year	Country	Type of study	Sample size	Objectives	Methodology	Results (excluding identification rates)
Alfieri 2006 (15)	Italy	Prospective cohort	973	To study the influence of nerve preservation vs division during hernioplasty	Surgeons at eleven centres were asked to report nerve identification and their preservation or division during the surgeries. They followed the patients for one year and wanted to study the chronic groin pain.	Non-identification of nerves or division of nerves was associated with chronic groin pain.
Bartlett 2007 (16)	UK	Prospective comparative cohort	172	Incidence of nerve division during the hernia surgery and its effect on pain	One hundred and seventy-two patients were operated. The pain scores in the groups with unidentified single nerve or divided single nerve or all identified and preserved nerves were recorded. They were compared for the differences.	Single nerve division during the hernia surgery is not associated with increased incidence of chronic groin pain.
Lange 2009 (17)	Netherlands	Prospective cohort	40	Feasibility of nerve recognizing Lichtenstein hernioplasty and measuring the extra time for it	Four experienced surgeons performed ten surgeries each at different centres. Nerve identification and the time taken for it was recorded.	Nerve recognizing Lichtenstein hernioplasty is feasible and non-time consuming. Major anatomical variations are uncommon.
Bischoff 2012 (18)	Denmark	Prospective comparative cohort	244	To study the effect of inguinal nerve identification on post-operative pain, sensory dysfunction and functional ability	Two surgeons performed the Lichtenstein inguinal hernioplasty and reported on nerve identification. After six months the outcome in patients were compared.	No difference in pain, sensory loss or functional outcome was observed in patients with or without nerve identification.
Sanders 2014 (19)	UK	Randomised controlled trial	507	Comparison of self-gripping mesh with suture fixation of mesh	Randomised controlled trial was performed at nine centres to study the pain scores at the time of discharge, seven days, three months and at one year. In one arm suture fixation was done and in another self-gripping mesh was employed. Identification of nerves was performed during the surgery.	Early post-operative pain at the time of discharge and at seven days was significantly less with self-griping mesh. No difference was observed for chronic pain at three months and at one year. Application of self-gripping mesh was less time consuming.
Grossi 2015 (20)	Brazil	Prospective cohort	38	Identification of three nerves during the surgery	After the surgery the data was entered as per the protocol of the study.	The identification rates were similar in emergency and the elective cases. The identification was difficult in recurrent cases.

Table 1. Characteristics of the included studies (continued)

Author year	Country	Type of study	Sample size	Objectives	Methodology	Results (excluding identification rates)
Mendes 2016 (21)	Brazil	Prospective comparative cohort	29	Neurotopographic adequacy of a transverse incision in Lichtenstein hernioplasty	Nerve identification in 29 inguinal hernia surgeries were compared with 10 groin dissections on cadavers. Transverse groin incision was used for surgery.	Nerve identification rates during hernia surgery on patients was comparable to groin dissections on cadavers.
Cirocchi 2020 (22)	Italy	Prospective cohort	115	Dermatome mapping test in inguinal hernia repair	One hundred and fifteen patients were followed for chronic postoperative neuropathic inguinal pain (CPIP). In the pre-operative period, the pain and its dermatomal distribution was recorded. Nerve identification was performed during the surgery. Post-operatively at sixth month, the CPIP and its dermatomal distribution was recorded. The effect of failure to identify nerves or its division on CPIP was evaluated.	CPIP is more prevalent when the nerves are not identified. It is more prevalent in the dermatome supplied by IIN and GB.

We performed the subgroup analysis of pooled prevalence for studies with a single primary objective vs studies with more than one primary objective and multicenter studies vs single center studies. The pooled prevalence in studies with a single primary objective was 0.88 (0.69-1.00). It was nearly the same in studies with more than one objective (0.84; 0.66-0.98) (Table 3A). The pooled prevalence in multicenter and single-center studies were 0.78 (0.58-0.95) and 0.95 (0.88-1.00), respectively (Table 3B).

Iliohypogastric Nerve (IHN)

The forest plot was constructed using the IVhet model (fixed effect, heterogeneity), as shown in Figure 2B. The pooled prevalence rate of IHN was 67% (95% CI 49-83%). Statistical heterogeneity was significant (Cochrane's Q 244.15, I2 97%, p< 0.001). On leave one out sensitivity analysis, the pooled prevalence varied from 69% to 79%. We analyzed the studies' funnel and DOI plots and detected major asymmetry. On multiple regression analysis, we found that none of the independent variables-sample size, centers of study and objectives significantly affected the IHN identification rates [model summary: R^2= 0.84, p= 0.14; coefficient: sample size (β= -0.55, p= 0.31), center (β= -0.13, p= 0.76), objective (β= 0.30, p= 0.46)].

On subgroup analysis, the pooled prevalence in studies with a single primary objective was 0.94 (0.85-1.00). It was 0.69 (0.49-0.88) in studies with more than one primary objective (Table 3A). The heterogeneity was not significant when two types of objectives were compared. This indicates that focused studies yield better identification rates for IHN. The pooled prevalence in multicenter and single-center studies were 0.54 (0.40-0.68) and 0.51 (0.12-0.90), respectively (Table 3B).

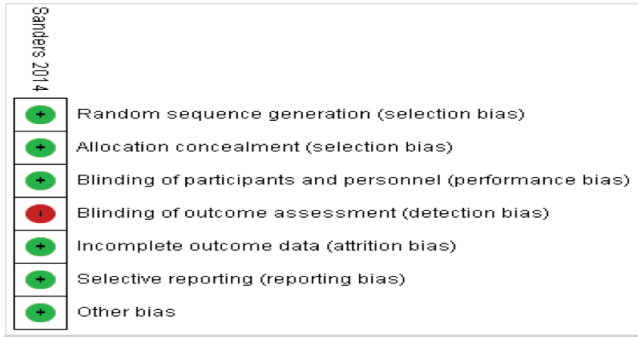
Genital Branch of Genitofemoral Nerve (GB)

The forest plot was constructed using the IVhet model (fixed effect, heterogeneity), as shown in the Figure 2C. The pooled prevalence rate of GB was 53% (95% CI 31-74%). Statistical heterogeneity was significant (Cochrane's Q 256.15, I2 97%, p< 0.001). The pooled prevalence varied from 49% to 57% on leave one out sensitivity analysis. We analyzed the studies' funnel and DOI plots and detected major asymmetry. On multiple regression analysis, we found that none of the independent variables-sample size, centers of study and objectives significantly affected the GB identification rates [model summary: R^2= 0.31, p= 0.64; coefficient: sample size (β= -0.26, p= 0.74), center (β= 0.27, p= 0.68), objective (β= -0.39, p= 0.53)].

On subgroup analysis, the pooled prevalence in studies with a single primary objective was 0.77 (0.52-0.97). It was 0.52 (0.30-0.73) in studies with more than one primary objective (Table 3A). The pooled prevalence in multicenter and single-center studies were 0.54 (0.40-0.68) and 0.51 (0.12-0.90), respectively (Table 3B).

Table 2. Quality assessment of the included articles

Quality assessment of comparative studies by Newcastle-Ottawa scale (NOS)									
	Selection				Comparability		Outcome			
Study	Representativeness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Demonstration that outcome of interest was not present at start of study	Adjust for the most important risk factors	Adjust for other risk factors	Assessment of outcome	Follow-up length	Loss to follow-up rate	Total quality score
Bartlett 2007	*	*	*	*	*	-	*	*	*	8
Bischoff 2012	*	*	*	*	-	-	*	*	-	6
Mendes 2016	*	*	*	*	*	*	*	*	*	9



Quality assessment of randomized controlled trial.

Studies with Nerve Identification as a Single Primary Objective vs Other Studies (Table 3A)

We found three articles where identifying nerves was the only primary objective. This subgroup included Lange 2009, Grossi 2015 and Mendes 2016. The sample size was small in each of the studies, with the largest being 40 in the study of Lange 2009. The identification rates were over 85% for all nerves except for IIN in Lange 2009 and GB in Grossi 2015 (75% and 52.6%, respectively). The pooled prevalence rates in this subgroup were 88%, 94% and 77% for IIN, IHN and GB, respectively. Heterogeneity was insignificant in the pooled value of IHN (p= 0.06) only. The identification rate of IHN was 94%, indicating a uniform identification in focused studies.

In five articles, there was more than one primary objective. This subgroup included Alfieri 2006, Bartlett 2007, Bischoff 2012, Sanders 2014 and Cirocchi 2020. The sample size ranged from 115 to 973. Alfieri 2006 reported poor identification rates for all nerves. Sanders 2014 reported low identification for IHN and GB (66.8% and 47.7%). Bischoff 2012 and Cirocchi 2020 observed a low prevalence of GB. The pooled prevalence in this subgroup was 84%, 69% and 52% for IIN, IHN and GB, respectively. Identification of IHN and GB was low by more than 20% compared to the other subgroup (94% & 77% vs 65% & 52%). The IIN rates differed only marginally in the two subgroups.

Multicenter vs Single Center Studies (Table 3B)

The studies of Alfieri 2006, Lange 2009 and Sanders 2014 were multi-centric. The sample size in the study of Lange 2009 was small. The other two studies were extensive. The nerve identification rate in single-center studies was 78%, 63% and 54% for IIN, IHN and GB, respectively. Heterogeneity was significant for all of the nerves.

Studies by Bartlett 2007, Bischoff 2012, Grossi 2015, and Mendes 2016 were conducted at a single center. The sample size ranged from 29 to 244. The pooled values for IIN, IHN and GB were 95%, 89% and 51%, respectively. More than a 20% increase in the identification of IIN and IHN was observed com-

Table 2. Quality assessment of the included articles

	Quality assessment of case series by JBI critical appraisal checklist									
Study	**Were there clear criteria for inclusion in the case series?**	**Was the condition measured in a standard, reliable way for all participants included in the case series?**	**Were valid methods used for identification of the condition for all participants included in the case series?**	**Did the case series have consecutive inclusion of participants?**	**Did the case series have complete inclusion of participants?**	**Was there clear reporting of the demographics of the participants in the study?**	**Was there clear reporting of clinical information of the participants?**	**Were the outcomes or follow up results of cases clearly reported?**	**Was there clear reporting of the presenting site(s)/ clinic(s) demographic information?**	**Was statistical analysis appropriate?**
Alfieri 2006	YES	YES	NO	UNCLEAR	YES	YES	YES	YES	YES	YES
Lange 2009	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Grossi 2015	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cirocchi 2020	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

pared to the other subgroup. However, the heterogeneity was significant for all nerves in this subgroup, as well.

Studies Detailing the Course of All Three Nerves During Surgery (Table 3C)

Lange et al. tried identifying the course of all three nerves during the surgery. The course of the nerves was recorded as standard anatomy or the variations. The surety of nerve identification was classified as: sure, probably sure, maybe, and probably not. They concluded that it is possible to identify IIN and IHN in most cases and significant anatomical variations are not observed. GB was difficult to recognize in at least 25% of the cases. The surgeons, in these cases, were unsure of the structure as a nerve or could not locate the blue vein near it. In an additional 12.5% (5/40) of the cases, they failed to identify it. They reported variations in the course of IIN in 15% (6/40) of the patients. Early branching over the spermatic cord was observed in these cases.

DISCUSSION

The pooled prevalence of IIN, IHN and GB was 81% (95% CI 64-96%), 67% (95% CI 49-83%) and 57% (95% CI 38-76%), respectively. There was significant heterogeneity in the pooled values. We evaluated a possible association of study sample size, centers of study and number of primary objectives with nerve identification rates but failed to find any. On subgroup analysis, poor identification rates of IIN were observed in multi-centric studies. A similar effect was seen on IHN in multi-centric studies and studies with more than one primary objective. GB was better recognized in studies with a single primary objective. The identification of IHN in studies with a single primary objective was the only subgroup where heterogeneity was not significant. These results indicate an acceptable good identification rate for IIN. The identification of IHN is adversely affected by the multicentricity and dilution in the focus of the study. The identification of GB is most difficult and probably unpredictable.

The anatomical location of inguinal nerves in the surgical field may explain some difficulties in their identification. The IIN lies on the spermatic cord. It may lie on the sac of an indirect (lateral) hernia or get displaced with the cord structures in a direct (medial) hernia. The nerve is frequently in the center of the surgical field, making identification easy. The IHN may be the most crucial regional nerve in respect to nerve entrapment during mesh fixation in open hernia repairs (25). It lies on the internal oblique muscle and its aponeurosis within the area of surgery. Its visualization needs retraction of the overlying external oblique aponeurosis. Its identification is difficult in comparison to IIN. Cirrochi 2018 also reported lower identification rates of IHN in their meta-analysis (26). The GB is thin compared to two other nerves and lies posteriorly in the spermatic cord. Its visualization requires

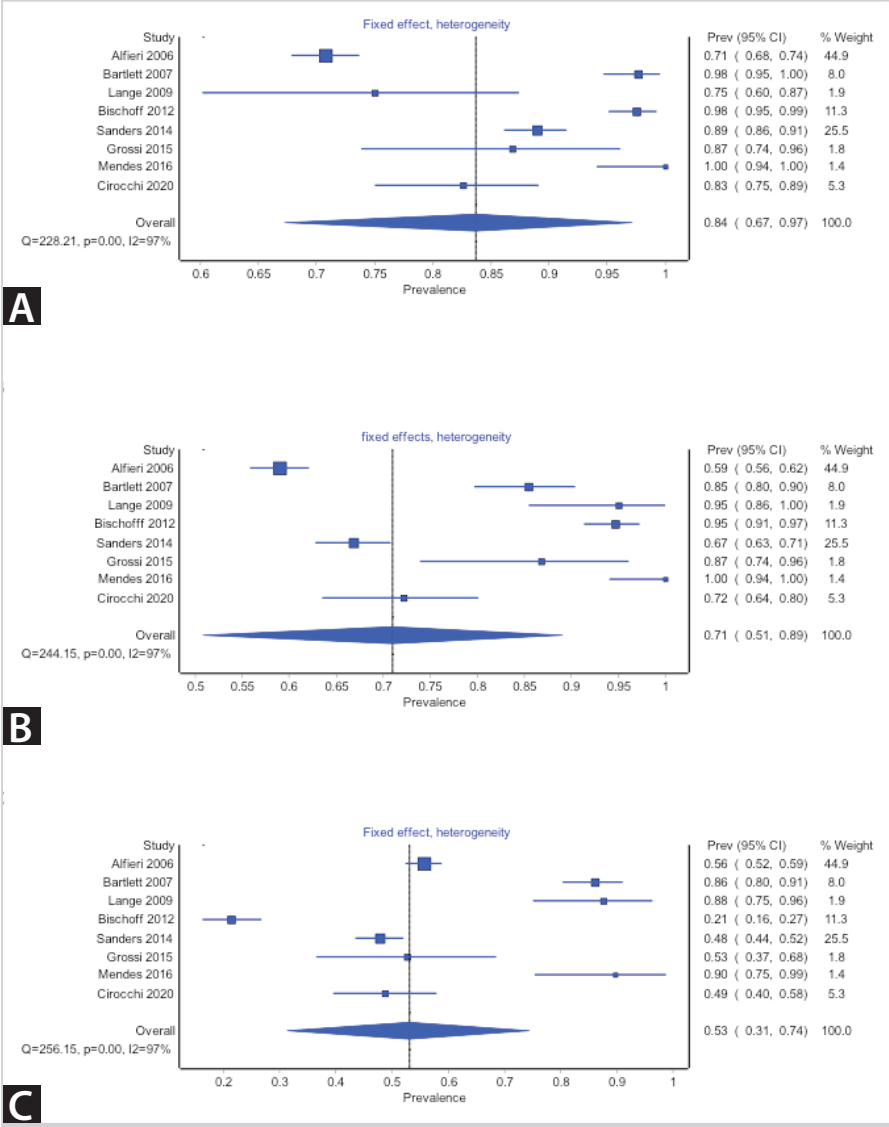


Figure 2. The forest plot of pooled prevalence under inverse variance heterogeneity model (IVhet model): **(A)** IIN, **(B)** IHN and **(C)** GB.

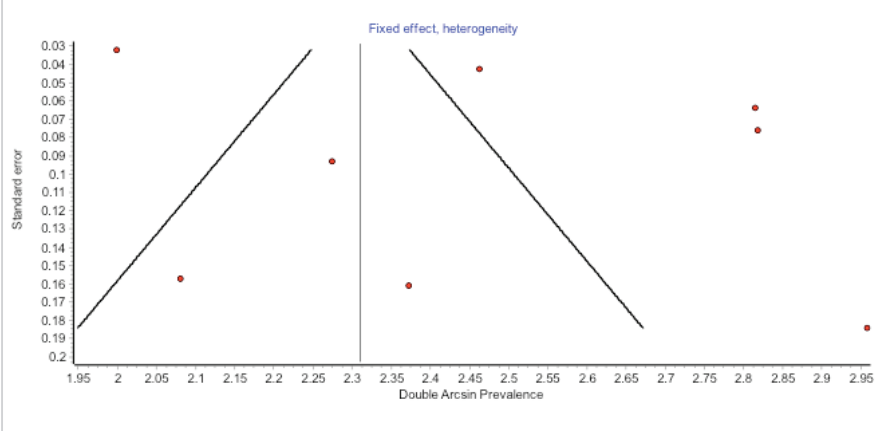


Figure 3. Funnel plot of the studies reporting IIN identification.

Table 3. The effect of study methodology on identification of nerves and description of the course of nerves

Table 3A. Studies with three nerve identification as single primary objective vs other studies

Studies with three nerve identification as single primary objective								
Author year	**Sample size**	**Identification rates (%)**			**Pooled prevalence (95% CI)**			
		IIN	**IHN**	**GB**		**IIN**	**IHN**	**GB**
Lange 2009	40	75	95	87.5	**IVhet model**	0.88 (0.69-1.00)	0.94 (0.85-1.00)	0.77 (0.52-0.97)
Grossi 2015	38	86.8	86.8	52.6				
Mendes 2016	29	100	100	89.7	**Q, P and I^2 statistics**	Q= 13.29 p< 0.01 I^2= 85%	Q= 5.74 p= 0.06 I^2= 65%	Q= 15.66 p< 0.01 I^2= 87%
Studies with three nerve identification not as single primary objective								
Alfieri 2006	973	70.8	59	55.6	**IVhet model**	0.84 (0.66-0.98)	0.69 (0.49-0.88)	0.52 (0.30-0.73)
Bartlett 2007	172	97.7	85.5	86				
Bischoff 2012	244	97.5	94.7	21.3				
Sanders 2014	557	89	66.8	46.8	**Q, P and I^2 statistics**	Q= 213.49 p< 0.01 I^2= 98%	Q= 193.02 p< 0.01 I^2= 98%	Q= 211.68 p< 0.01 I^2= 98%
Cirocchi 2020	115	82.6	72.2	48.7				

Table 3B. Nerve identification in multicentre vs single centre studies

Multi-centre studies								
Author year	**Sample size**	**Identification rates (%)**			**Pooled prevalence (95% CI)**			
		IIN	**IHN**	**GB**		**IIN**	**IHN**	**GB**
Alfieri 2006	973	70.8	59	55.6	**IVhet model**	0.78 (0.58-0.95)	0.63 (0.48-0.77)	0.54 (0.40-0.68)
Lange 2009	40	75	95	87.5				
Sanders 2014	557	89	66.8	47.7	**Q, P and I^2 statistics**	Q= 75.81 p< 0.01 I^2= 97%	Q= 36.78 p< 0.01 I^2= 95%	Q= 31.90 p< 0.01 I^2= 94%
Single centre studies								
Bartlett 2007	172	97.7	85.5	86	**IVhet model**	0.95 (0.88-1.00)	0.89 (0.77-0.98)	0.51 (0.12-0.90)
Bischoff 2012	244	97.5	94.7	21.3				
Grossi 2015	38	86.8	86.8	52.6				
Mendes 2016	29	100	100	89.7	**Q, P and I^2 statistics**	Q= 32.63 p< 0.01 I^2= 88%	Q= 41.81 p< 0.01 I^2= 90%	Q= 223.09 p< 0.01 I^2= 98%
Cirocchi 2020	115	82.6	72.2	48.7				

lifting and twisting of the cord. The difficult identification of GB is well-reported in the surgical literature (18,19,21,22).

The anatomical studies on cadavers report better identification of nerves. Cirrochi 2018 conducted a meta-analysis that included cadaveric and surgical studies. They have calculated 87% and 76.3% for IIN and IHN as the pooled prevalence. On subgroup analysis, the identification of IIN and IHN in cadavers was 98% and 99% (26), which indicates that the identification of nerves during surgery is more challenging than that on the cadavers. Multiple factors may play a role in this. The surgical field is blood-tinged, and the surgeon is more concerned about identifying and separating the hernia sac in the early steps. Lack of proper anatomical knowledge makes identifying the nerves in the inguinal region complex. This is especially true for IHN and GB, which are not in the center of the surgical field (27). The use of synthetic Mesh has made the surgery simple, and surgeons do not spare more time searching for a nerve.

Limited studies have reported the course of inguinal nerves during surgery. Lange 2009 found that the course of IHN was classical in all cases. They also said the course of IIN was classical

Table 3C. Study detailing the course of all three nerves (lange 2009)

Author	The standard anatomy	The details of variations observed
Lange 2009	IHN The nerve is horizontal and ventral to the internal oblique. It arises 2.4 (range 1.5-4.4) cm cranial to the internal ring and perforates the external oblique at 3.8 (range 2.5-5.5) cm cranial to the superficial ring. In 11%, it is inside IO and invisible. IIN The nerve is ventral and parallel to the spermatic cord. It runs dorsal to the external oblique. GB The nerve is found lying laterocaudally to the internal ring. It runs parallel to the cremasteric artery and vein called the 'blue line'.	IHN (38/40) All classical, and all identified as "for sure." IIN (30/40) 24 classical 6 branched over the spermatic cord All identified as "for sure." GB (35/40) Doubtful= 10 (probably sure= 3, May be= 5, Probably not= 2) Reasons for doubt 3= Not following blue line, 4= Structure might be vessel or muscle fibre 3= No reasons explained

in 75% of the cases. They could identify both these nerves in all cases (17). The course of IIN and IHN was also studied by Al-dabbagh 2002 and Emeksiz 2016. They reported the course as classical in only 50% of the cases. Their observations were based on a larger sample size (13,14). The anatomical studies on cadavers also report massive variation in the course of IHN and IIN (28,29).

The identification of GB is the most challenging. In the study by Cirrochi 2018, the pooled prevalence was 48.2% (26). Bischoff has identified this nerve in only 21.3% of the cases (18). This nerve runs close to the external spermatic vein and is called the blue vein. In case of difficulty, the nerve is presumed to be identified once the external spermatic vein is seen. This technique is seen in the study of Lange 2009 who identified GB in 35 out of 40 cases. They reported that they were unsure of the finding in at least 10 cases.

The values of pooled prevalence of the nerves are not suitable as the quality standard for hernia surgery. The presence of significant heterogeneity reduces the quality of pooled values. In our study, on subgroup analysis, better identification rates were observed for IIN and IHN in single-center studies. Further, in one subgroup with a single primary objective as nerve identification, heterogeneity was low for IHN identification. The pooled prevalence in this subgroup was 94%. This all suggests a possibility of better nerve identification with focused and motivated centers. Even if we use IIN as a quality standard, there is a probability of missing the nerve in 16% of the surgeries. The identification rates of the other two nerves, IHN and GB, are poor. We should continue identifying the nerves as this practice probably reduces the chances of debilitating chronic inguinodynia.

The objectives of our study were focused. We excluded studies on cadaveric dissection and studies that failed to report on all three nerves. The selected studies were recent, and their methodological quality was good to excellent. Nerve identification was the primary objective in all articles. The pooled findings indicate that higher identification rates of cadaveric studies are challenging to reproduce.

There are a few limitations of this study. The number of included studies was small, and they belonged to Europe or North America only. The study methodology was not uniform and included randomized controlled trials, prospective comparative cohort studies and prospective non-comparative cohort studies. Methodological quality assessment used three different tools. The detection of publication bias with funnel plot was unreliable as the number of included studies was less than ten (30). Due to the scarcity of data, we could not analyze the effect of some variables such as, body mass index, anthropometry and emergency surgery, on nerve identification rates.

More studies are needed that describe the course of inguinal nerves at the time of surgery. The studies should aim at simplifying the types of possible variation in the course of nerves. Further research is also needed to understand the feasibility of nerve identification in emergency surgeries.

CONCLUSION

This was a systematic review and meta-analysis of articles reporting the identification of all three inguinal nerves in open hernia surgery. The identification rates of none of the nerves were near 90% in the pooled estimates. It was even less in multi-centric studies and studies with more than one primary objective. The lowest identification rate was observed for the

genital branch of the genitofemoral nerve. A comprehensive description of the course of the nerves was not seen in most of the studies. Based on nerve identification rates from this pool of studies, it is difficult to suggest a benchmark for the quality assessment of hernia surgery.

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ORİJİNAL ÇALIŞMA-ÖZET
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Açık inguinal hernioplastide sinir tespiti: Bir meta-analiz

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ÖZET

Giriş ve Amaç: Açık inguinal hernioplastide cerrahi alanda üç kasık siniri ile karşılaşılır. Dikkatli diseksiyon, postoperatif kasık ağrısı riskini azalttığından, bu sinirlerin tanımlanması tavsiye edilir. Ameliyat sırasında sinirleri tanımak zor olabilir. Sınırlı sayıda cerrahi çalışma, tüm sinirlerin tanınma oranlarını bildirmiştir. Bu çalışmanın amacı, bahsi geçen çalışmalardaki her bir sinirin karma prevalansını hesaplamak ve sinirleri bulmanın ortalama olasılığını anlamak ve önemlerini analiz etmekti.

Gereç ve Yöntem: PubMed, CENTRAL, CINAHL, ClinicalTrials.gov ve Research Square veri tabanları tarandı. Ameliyat sırasında üç sinirin de prevalansını bildiren makaleler seçildi. Meta-analiz, sekiz çalışmadan elde edilen veriler üzerinde gerçekleştirildi. *Forest plot* hazırlamak için MetaXL yazılımından IVhet modeli kullanıldı. Heterojenliğin nedenini anlamak için alt grup analizi yapıldı.

Bulgular: İlioinguinal sinir (IIN), iliohipogastrik sinir (IHN) ve genitofemoral sinirin (GB) genital dalı için karma prevalans oranları sırasıyla %84 (%95 GA %67-97), %71 (%95 GA %51-89) ve %53 (%95 GA %3174) idi. Alt grup analizinde, tek merkezli çalışmalarda ve sinir tanımlaması gibi tek bir birincil amacı olan çalışmalarda tanımlama oranları daha yüksekti. Heterojenite, tek merkezli çalışmalarda IHN tanımlama oranlarının alt grup analizi hariç tüm karma değerlerde anlamlıydı.

Sonuç: Sonuçlar IHN ve GB için düşük tanımlama oranlarına işaret etmektedir. Belirgin heterojenlik ve geniş güven aralıkları, IHN ve GB'nin kalite standartları anlamında önemini azaltmaktadır. Tek merkezli ve sinir tanımlamaya odaklanan çalışmalarda daha iyi sonuçlar gözlenmektedir.

Anahtar Kelimeler: Hernioplasti, inguinal herni, periferik sinirler

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