CLINICAL AND SURGICAL OUTCOMES OF POSTERIOR ENDOSCOPIC SURGERY ON THE CERVICAL SPINE IN THE TREATMENT OF CERVICAL PATHOLOGIES

DESFECHOS CLÍNICOS E CIRÚRGICOS DAS CIRURGIAS ENDOSCÓPICAS POSTERIORES NA COLUNA CERVICAL NO TRATAMENTO DAS PATOLOGIAS CERVICAIS

RESULTADOS CLÍNICOS Y QUIRÚRGICOS DE LA CIRUGÍA ENDOSCÓPICA POSTERIOR DE LA COLUMNA CERVICAL EN EL TRATAMIENTO DE PATOLOGÍAS CERVICALES

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ABSTRACT

Posterior endoscopic cervical discectomy (PECD) and foraminotomy (PECF) present comparable clinical outcomes to traditional open surgeries. The objective of this study is to evaluate, through systematic review and meta-analysis, the clinical and surgical outcomes of cervical endoscopy techniques using the posterior approach. The search criteria followed the following pattern: "((posterior endoscopic surgery) AND ((clinical outcomes) OR (surgical outcomes))) AND (cervical spine) Filters: from 2013 to 2023". Only original articles in English or Portuguese were included in the review. The search resulted in the inclusion of 45 studies, totaling 1,973 patients. The estimated mean surgical time was 76 minutes, while the estimated mean blood loss was 42 mL. The mean hospital stay was 4 days, with a mean ICU stay of 0.25 days. The techniques were able to promote significant improvements in quality-of-life scores. It was concluded that endoscopic techniques can significantly improve quality scores, with very low blood loss and surgical time. ***Level of Evidence I; Systematic Review and Meta-analysis.***

Keywords: Endoscopy; Surgery; Systematic Review; Meta-analysis.

RESUMO

A discectomia cervical endoscópica posterior (PECD) e a foraminotomia (PECF) apresentam resultados clínicos comparáveis às cirurgias abertas tradicionais. O objetivo deste estudo é avaliar, por meio de revisão sistemática e metanálise, os desfechos clínicos e cirúrgicos das técnicas de endoscopia cervical pela abordagem posterior. Os critérios de busca seguiram o seguinte padrão, "((posterior endoscopic surgery) AND ((clinical outcomes) OR (surgical outcomes))) AND (cervical spine) Filtros: de 2013 a 2023". Apenas artigos originais em inglês ou português foram incluídos na revisão. A busca resultou na inclusão de 45 estudos, que totalizaram 1973 pacientes, o tempo médio estimado de cirurgia foi de 76 minutos, já a média de perda sanguínea estimada foi de 42 mL. O tempo médio de internação foi de 4 dias, com tempo médio de UTI de 0,25 dias. As técnicas foram capazes de promover melhora significativa nos escores de qualidade de vida. Concluiu-se que técnicas endoscópicas são capazes de promover melhora significativa nos escores de qualidade, com um baixíssimo volume de perda sanguínea e tempo cirúrgico. ***Nível de Evidência I; Revisão Sistemática e Metanálise.***

Descritores: *Endoscopia; Cirurgia; Revisão Sistemática; Metanálise.*

RESUMEN

La discectomía cervical endoscópica posterior (PECD) y la foraminotomía (PECF) presentan resultados clínicos comparables a los de las cirugías abiertas tradicionales. El objetivo de este estudio es evaluar, mediante una revisión sistemática y un metaanálisis, los resultados clínicos y quirúrgicos de las técnicas de endoscopia cervical mediante abordaje posterior. Los criterios de búsqueda siguieron el siguiente patrón: "((cirugía endoscópica posterior) AND ((resultados clínicos) OR (resultados quirúrgicos))) AND (columna cervical) Filtros: de 2013 a 2023". Solo se incluyeron en la revisión artículos originales en inglés o portugués. La búsqueda resultó en la inclusión de 45 estudios, con un total de 1973 pacientes. El tiempo quirúrgico medio estimado fue de 76 minutos, mientras que la

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pérdida sanguínea media estimada fue de 42 ml. La estancia hospitalaria media fue de 4 días, con una estancia media en la UCI de 0,25 días. Las técnicas lograron mejoras significativas en la calidad de vida. Se concluyó que las técnicas endoscópicas pueden mejorar significativamente la calidad de vida, con una pérdida sanguínea y un tiempo quirúrgico muy bajos. ***Nivel de Evidencia I; Revisión Sistemática y Metaanálisis.***

Descriptores: *Endoscopía; Cirugía; Revisión Sistemática; Metaanálisis.*

INTRODUCTION

Pain in the cervical spine due to degenerative disc disease (DDD) can affect up to 67% of people aged 50 or older. The incidence of hospitalization due to degenerative cervical myelopathy was estimated at 4.04 per 100,000 inhabitants, being lower than the incidence of radiculopathy[1].

The posterior cervical decompression and foraminotomy are established procedures, widely used over the years, with satisfactory clinical results. These techniques allow the decompression of the nerve root without the need to fix the vertebral segment, preserving the mobility of the operated region. However, the subsequent approach requires extensive exposure and detachment of the paravertebral muscles, which may lead to significant morbidity and increase the risk of postoperative kyphosis[2].

The anterior decompression of the cervical spine, with or without arthrodesis or arthroplasty, represents an effective alternative in the treatment of cervical degenerative diseases. Although clinically favorable, this approach is not exempt from complications, which may include dysphagia, injury to adjacent structures and failures in bone fusion[3,4].

Among minimally invasive techniques, endoscopic surgery represents an effective alternative, allowing decompression of neural structures without the need for extensive exposure or detachment of the paravertebral muscles, as occurs with conventional open approaches[2,5,6]. Posterior endoscopic cervical discectomy (PECD) and posterior endoscopic foraminotomy (PECF) are minimally invasive techniques indicated for the treatment of cervical radiculopathy, offering clinical results comparable to those of traditional open surgeries. Compared to conventional approaches, these less invasive methods are associated with reduced postoperative pain, reduced surgical morbidity, reduced muscle spasm and reduced incidence of postoperative functional dysfunction[5,7].

The aim of this study is to evaluate, through systematic review and meta-analysis, the clinical and surgical outcomes of cervical endoscopy techniques by the subsequent approach.

MATERIAL AND METHODS

Research and Recovery Strategy

The electronic databases, including PubMed, Google Scholar, Ovid and BVS, have been systematically reviewed using the following search strategy: Search: "(posterior endoscopic surgery) AND (clinical outcomes) OR (surgical outcomes) AND (cervical spine) Filters: from 2013 to 2023". Only original articles in English or Portuguese were included in the review.

Selection and inclusion criteria

The study was conducted in two stages. The first consisted of a brief analysis of the title/resume, in which the authors sought evidence to decide whether or not the work should move forward to the next stage. At this stage, the articles that raised doubts about the compliance with the inclusion criteria were forwarded to the second stage. In the second stage, the authors conducted the verification of the full text of the remaining articles. At present, the criteria for inclusion were as follows: (i) the article presents a post endoscopic technique for the cervical region; (ii) the article presents clinical or surgical outcomes of the technique; (iii) the article is a randomized clinical trial, or a prospective study, or a retrospective study; (v) patients undergoing surgery for degenerative pathologies of the cervical region.

Data extraction

The inclusion of continuous variables occurred only if the article informed the standard deviation or other information that allowed the calculation of the standard deviation for each group. Studies presenting two or more subgroups were divided by the number of subgroups presented, adding the "-x" next to the article ID (Ex: A-1, A-2).

Quality Assessment

To evaluate the quality of the included articles two tools were used: for Randomized Clinical Trials, the Cochrane Foundation's RoB-Risk2 tool, and the Newcastle Ottawa (NOS) scale for prospective and retrospective cohort studies.

Statistical analysis

Multiple studies were conducted of single-arm meta-analysis (*single-arm meta-analysis*) for clinical outcomes, meta-analysis of averages (*meta-mean*) for surgical outcomes and meta-analysis of proportions (*meta-proportion*) for outcomes of complications. The results for single-arm continuous variables were presented as standardized mean differences (MD), while the continuous meta-analysis variables of averages were presented as averages, and proportional data were presented as the proportion of occurrences in the total population presented in the analysis. The heterogeneity between the studies was evaluated using the Cochran Q statistical test, and the heterogeneity between the studies included was evaluated using the qui-square test, with $p < 0.05$ indicating heterogeneity. In the presence of heterogeneity, the model of random effects was employed, and in other cases, the model of fixed effects. P values lower than 0.05 were considered significant.

RESULTS

392 articles were identified through the review of the databases, inclusion by bibliographic references and personal collection. In the first stage of selection, 11 duplicate articles were excluded. Then, in the sorting of the summaries, 286 articles (75%) were discarded because they did not meet the inclusion criteria. The remaining 95 articles were evaluated for the availability of the full text, language and thematic relevance, resulting in the exclusion of 50 articles (52%). Thus, 45 articles were included in the final analysis (Figure 1).

Of the 45 studies, 12 presented data from more than one procedure of interest, so 57 entries were evaluated. The title, authors and basic data of each study are shown in Table 1. Of the 57 entries, 27 used PECD, 25 used the PECF technique, 1 transpedicular technique, 1 percutaneous endoscopic lateral access (PELA) and 1 percutaneous endoscopic laminoforaminotomy technique (PECLF).

As for the methodological quality of the studies included, 42 were retrospective, 2 randomized clinical trials and 1 prospective. On average, the retrospective and prospective studies showed a score of 6 points, ranging from 5 to 7. The randomized clinical trials were evaluated with the level of 'some concern' on the RoB-2 scale, mainly due to the absence of appropriate methods of randomization and the limitations of blindness inherent to the surgical techniques used.

Surgical outcomes

In the analysis of surgical time, 44 entries were included. The heterogeneity between the studies was considered high (I2 = 99%), which justified the adoption of the model of random effects. The estimated average surgical time was 76 minutes (95% confidence interval: 70.4 – 81.5) (Figure 2).

The high heterogeneity between the data (I2 = 99%) justified

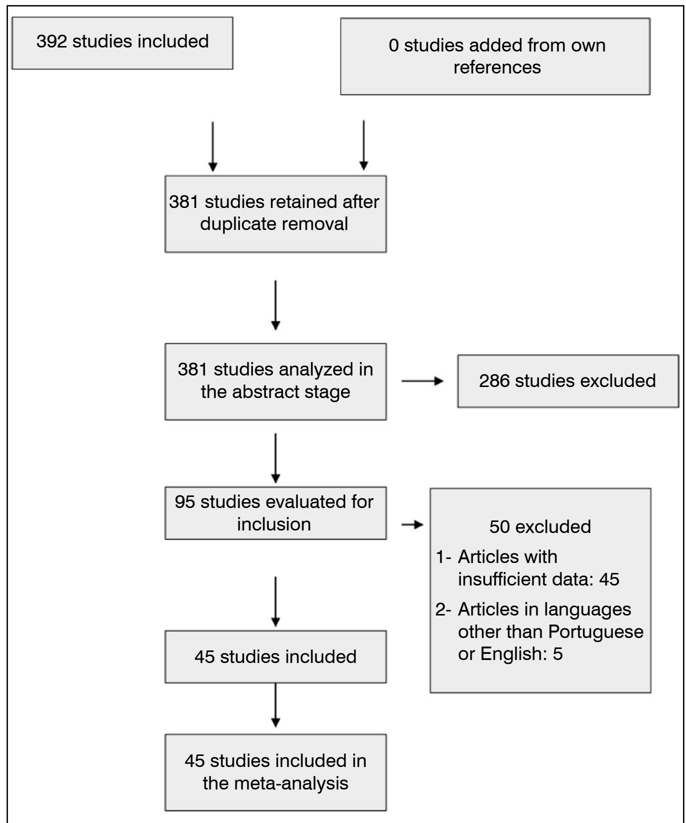

Figure 1. Review and inclusion flow of articles according to PRISMA standardization.

the use of the random effects model, resulting in an average of 76 minutes (95% CI: 70.4–81.5).

For the analysis of intraoperative blood loss, 15 entries were included. High heterogeneity was also observed (I2 = 99%), leading to the application of the same statistical model. The estimated mean blood loss was 42 milliliters (95% confidence interval: 31.4 – 51.1). No significant differences were observed between subgroups of surgical techniques (PECF, PECD or PECLF). In meta-regression (or meta-analysis regression), it was identified that surgeries involving two levels presented a higher volume of bleeding compared to one level surgeries (Figure 3).

In the analysis of admission time, 37 entries were included. The heterogeneity between the studies was considered high (I2 = 97.5%), which justified the adoption of the model of random effects. The estimated average hospitalization time was 5 days (95% confidence interval: 4.2 – 5.5). Patients undergoing the PCLF technique presented higher hospitalization times compared to other surgical approaches (Figure 4).

As for the occurrence of complications, a meta-analysis of proportions with 56 entries was carried out. Although the heterogeneity was lower than observed in the other analyses, it was still considered significant (I2 = 58.2%), and the model of random effects was also applied. The overall proportion of complications was 0.04 (95% confidence interval: 0.029 – 0.064). The use of the PECD technique demonstrated a protective effect in reducing the rate of complications compared to other approaches. In addition, studies that included exclusively the treatment of disc hernia showed lower proportions of complications (Figure 5).

Clinical outcomes

As for postoperative clinical outcomes, 39 entries were included in the analysis of the intensity of cervical pain by visual analogous

Table 1. Basic data regarding the included articles. Values followed by points represent that more than one study group was used (e.g.: X.1).

First Author	Year	ID	Type of Study	Technical type	Modifications	Pathologies
Yu, Ke-Xiao[8]	2020	1	Retrospective	Transpedicular		Mixed
Kim, Ji Yeon[9]	2022	3.1	Retrospective	PECF		Foraminal bone stenosis
Kim, Ji Yeon[9]	2022	3.2	Retrospective	PECF	Technical modifications	Foraminal bone stenosis
Ji-Jun, Huang[10]	2020	6	Prospective	PECD		Mixed
Yao, Shudan[11]	2020	11	Prospective	PECD		Mixed
Youn, Myung Soo[12]	2017	45	Retrospective	PECF		Mixed
Haijun, Ma[13]	2020	48.1	Retrospective	PECD	Translaminar Key-Hole	Mixed
Haijun, Ma[13]	2020	48.2	Retrospective	PECD	Translaminar Delta-System	Mixed
Jung, Seok Bong[14]	2022	65	Retrospective	PECD		Disk Herniation
Xiao, Chang-Ming[15]	2019	76.1	Retrospective	PECD		Mixed
Xiao, Chang-Ming[15]	2019	76.2	Retrospective	PECD	Partial Pediculectomy	Mixed
Hou, Guo-Li[16]	2022	83	Retrospective	PECF		Foraminal bone stenosis
Wen, Hongquan[17]	2017	90	Retrospective	PECD	Full-endoscopic	Disk Herniation
Heo, Dong Hwa[18]	2023	91	Retrospective	PECF		Foraminal stenosis
Kang, Min-Seok[19]	2022	110.1	Retrospective	PECF	Full-endoscopic	Foraminal stenosis
Kang, Min-Seok[19]	2022	110.2	Retrospective	PECF	Biportal	Foraminal stenosis
Song, Kwan-Su[20]	2020	111	Retrospective	PECF	Inclined Biportal	Mixed
Liao, Conggang[21]	2018	112.1	RCT	PECD		Disk Herniation
Liao, Conggang[21]	2018	112.2	RCT	PECD	Vertical Anchoring	Disk Herniation
Park, Jae Hyun[22]	2017	115	Retrospective	PECD		Disk Herniation
Zhong, Guibin[23]	2022	117	Retrospective	PECD		Mixed
Kim, Chi Heon[24]	2015	123	Retrospective	PECD		Mixed

First Author	Year	ID	Type of Study	Technical type	Modifications	Pathologies
Tong, Yuexin[25]	2020	130.1	Retrospective	PECD	Ventral Bony Decompression	Foraminal stenosis
Tong, Yuexin[25]	2020	130.2	Retrospective	PECD	Simple Dorsal Decompression	Foraminal stenosis
Kim, Ji Yeon[26]	2022	139.1	Retrospective	PECF	Uniportal	Foraminal stenosis
Kim, Ji Yeon[26]	2022	139.2	Retrospective	PECF	Biportal	Foraminal stenosis
Kim, Hyeun Sung[27]	2020	150	Retrospective	PECF	Partial Pediculectomy and vertebrectomy	Mixed
Kim, Hyeun Sung[28]	2023	154	Retrospective	PECD	Partial Pediculectomy	Mixed
Oertel, Joachim M K[29]	2016	157	Retrospective	PECF		Foraminal stenosis
Xiao, Qingqing[30]	2023	166	Retrospective	PELA		Disk Herniation
Yu, Tong[31]	2021	172.1	Retrospective	PECD	3.7 mm	Disk Herniation
Yu, Tong[31]	2021	172.2	Retrospective	PECD	6.9mm	Disk Herniation
Shen, Jian[32]	2020	177	Retrospective	PECF		Mixed
Akiyama, Masahiko[33]	2020	183	Retrospective	PECF	Full-endoscopic	Mixed
Shu, Wei[34]	2019	188	Retrospective	PECD		Mixed
Zhang, Chao[35]	2018	190	Retrospective	PECF		Mixed
Dinh, Son Ngoc[36]	2022	194	Retrospective	PECD	Full-endoscopic	Foraminal stenosis
Shi, Changgui[37]	2021	202	Retrospective	PECD		Mixed
Yao, Ran[38]	2022	205	Retrospective	PECLF		Mixed
Paik, Seungyoon[39]	2023	207.1	Retrospective	PECF	Full-endoscopic	Disk Herniation
Paik, Seungyoon[39]	2023	207.2	Retrospective	PECF	Full-endoscopic	Foraminal stenosis
Won, Samuel[40]	2017	215	Retrospective	PECF		Disk Herniation
Liu, Yi[41]	2021	218	Retrospective	PECD		Disk Herniation
Zhong, Zhuolin[42]	2023	221.1	Retrospective	PECF	Full-endoscopic	Mixed
Zhong, Zhuolin[42]	2023	221.2	Retrospective	PECF	Unilateral biportal	Mixed
Chen, Yuanyuan[43]	2023	222	Retrospective	PECD		Mixed
Sun, Xiao[44]	2023	229	Retrospective	PECF		Disk Herniation
Wang, Dong[45]	2023	235.1	Retrospective	PECD	Unilateral Biportal	Mixed
Wang, Dong[45]	2023	235.2	Retrospective	PECD	Full-endoscopic	Mixed
Gong, Shuangquan[46]	2023	315	Retrospective	PECD	Trench	Mixed
Yang, Jun-Song[47]	2014	357	Retrospective	PECD	Full-endoscopic	Disk Herniation
Kang, Min-Seok[48]	2023	365.1	Retrospective	PECF	Biportal	Mixed
Kang, Min-Seok[48]	2023	365.2	Retrospective	PECF	Biportal	Mixed
Ye, Zhi-Yuan[49]	2017	371	Retrospective	PECF	Full-endoscopic	Foraminal bone stenosis
Yu, Ke-Xiao[50]	2019	389	Retrospective	PECD	Trench	Disk Herniation
Ruetten, Sebastian[51]	2008	390	RCT	PECF	Full-endoscopic	Disk Herniation
Liu, Chao[52]	2019	391	Retrospective	PECD	Lamina-hole	Disk Herniation

scale (VAS). As in the other analyses, high heterogeneity was observed between the studies (I2 = 96.2%), which justified the use of the model of random effects. The mean difference between pre- and postoperative periods was -5.2 points (95% Confidence Interval: -5.6 to -4.8), indicating significant improvement in cervical pain after the procedure (Figure 6).

In relation to the functional disability score evaluated by the instrument *Neck Disability Index* (NDI), 34 entries were analyzed, with equally high heterogeneity (I2 = 99%). The average difference observed between pre- and postoperative was -27.5% (95% Confidence Interval: -31.3% to -21.2%), showing significant functional improvement. No statistically significant differences were identified in the reduction of NDI between the different surgical techniques evaluated (Figure 7).

The results of the variables analyzed, including the number of entries, number of patients, estimates of effect and respective confidence intervals, are presented in Table 2.

DISCUSSION

Recent studies have shown that endoscopic techniques are associated with lower rates of complications, reduced opioid administration and faster return to work. These benefits, when combined with the application of standardized postoperative recovery protocols, such as the '*Enhanced Recovery After Surgery*' (ERAS), reinforce the potential of endoscopic approaches as effective and less invasive alternatives in the treatment of cervical spine pathologies[53,54]. The present study analyzed the surgical and clinical outcomes resulting from the application of subsequent endoscopic techniques in the treatment of degenerative diseases of the cervical spine.

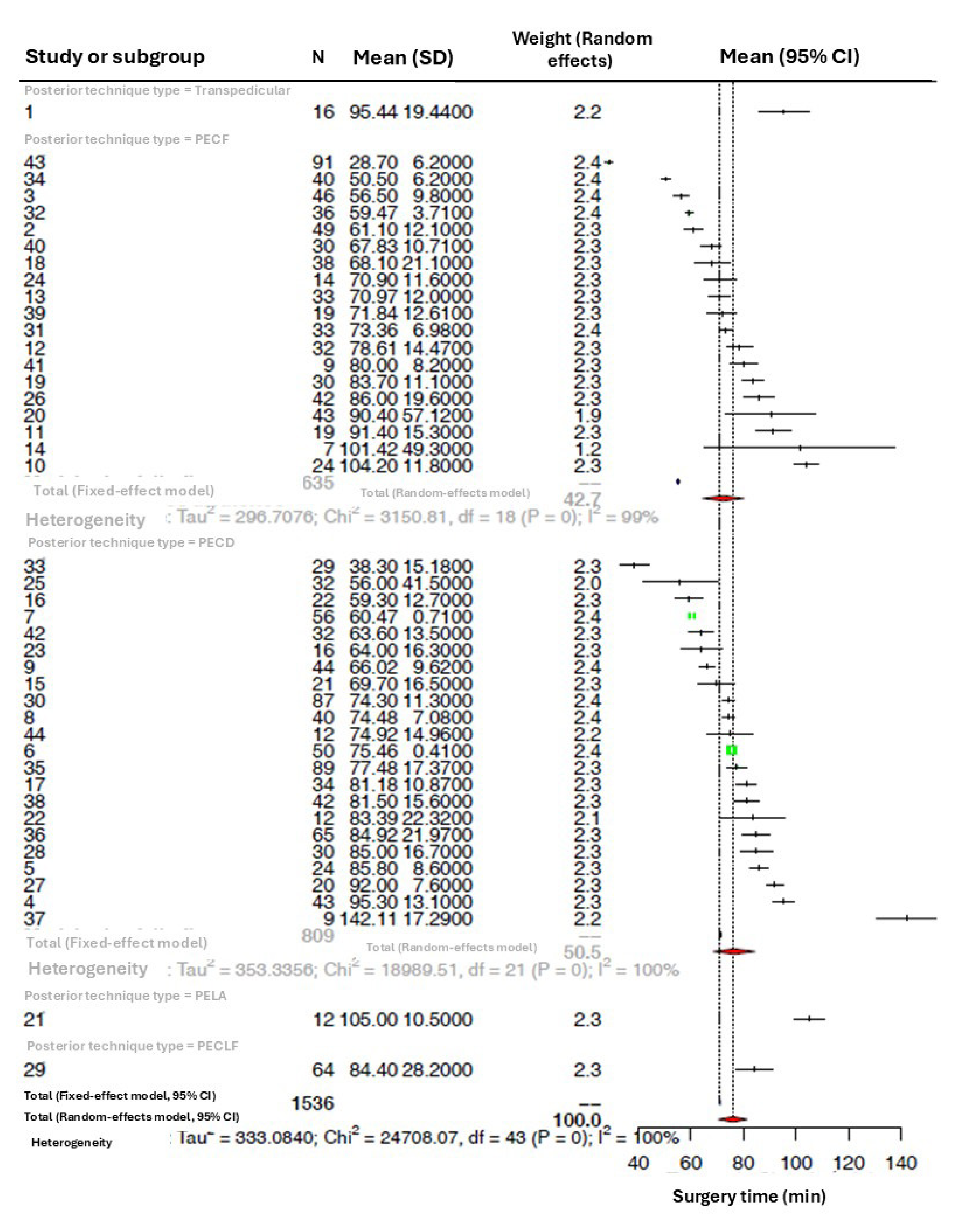

Figure 2. Estimate of surgical time based on 44 studies included. The high heterogeneity between the data (I2 = 99%) justified the use of the random effects model, resulting in an average of 76 minutes (95% CI: 70.4–81.5).

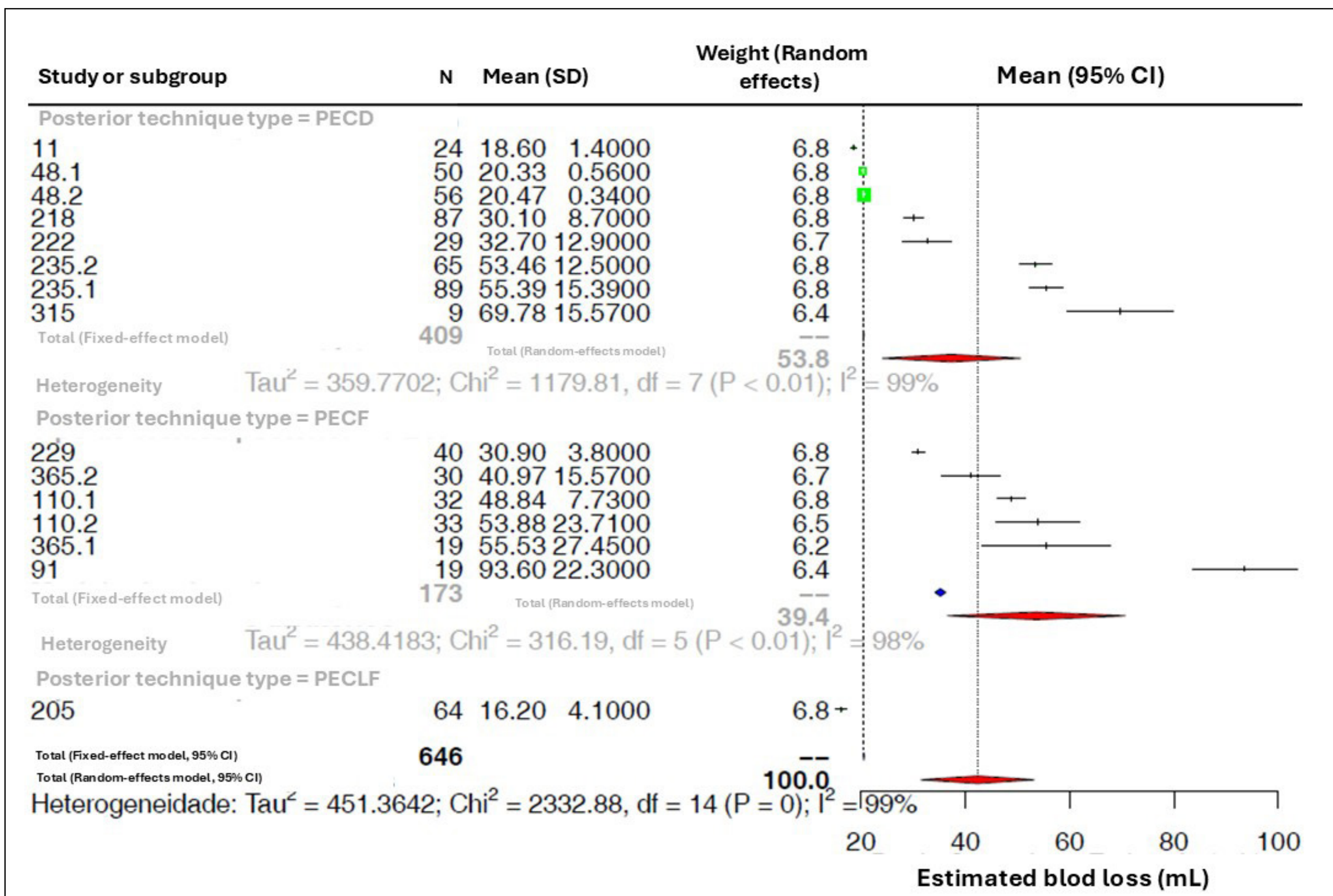

Figure 3. Estimate of intraoperative blood loss based on 15 included studies. The high heterogeneity (I2 = 99%) justified the use of the random effects model, resulting in an average of 42 ml (95% CI: 31.4–51.1). There were no significant differences between subgroups of surgical techniques (PECF, PECD, PECLF). The meta-regression indicated a higher volume of bleeding in two-level surgeries compared to one-level surgeries.

The PECF technique has as its main goal the decompression of the cervical nerve roots through the enlargement of the foraminal space, and may include discectomy in cases with lateralized disc fragments. Studies that evaluated the clinical outcomes of fully endoscopic PECF in the treatment of foraminal bone stenosis have demonstrated favorable clinical and surgical results[55]. In addition, PECF presented results comparable to those of conventional microscopic technique. However, due to the need for a significantly smaller area for foraminotomy, patients undergoing PECF report reduced use of postoperative pain medications[33].

PECD and PECF are among the most widely used techniques for endoscopic procedures in the cervical region[56]. Both PECD and previous discectomy have similar clinical outcomes. However, PECD is associated with lower average volume of removed disc and a discrete reduction in hospital stay[47].

Some studies also show that performing partial pediculectomy can be an effective strategy in cases of foraminal stenosis, contributing to the enlargement of the neural space and promoting improvement in surgical and clinical outcomes in the postoperative period[15,28].

Recent literature reviews have also investigated the clinical outcomes of the PECF technique. PECF approaches demonstrated significant improvement in multiple quality of life scores, including cervical EVA, upper limb EVA and NDI, in addition to presenting a very low rate of complications (0.03)[57].

In addition, a meta-analysis comparing the techniques of PECF and previous discectomy with fusion (ACDF) in cases of unilateral radiculopathy without myelopathy showed that endoscopic approaches are equally effective, promoting significant improvement in clinical scores of cervical pain (EVA) and functional disability (NDI)[58].

In addition, one study revealed that there was no significant difference in the overall profile of complications between fully endoscopic and microendoscopic PECF techniques. However, the authors observed that the fully endoscopic approach presented a higher rate of transient nerve root paralysis, possibly related to direct manipulation during the procedure[59].

Limitations

Among the limitations of this study, the high number of retrospective studies included, as well as the high heterogeneity observed both within and between the analyzed groups, stand out. To mitigate these factors, the model of random effects was adopted in the analyses in which heterogeneity exceeded the threshold of 50%.

CONCLUSION

PECF and PECD techniques are among the most widely used approaches for endoscopic posterior cervical decompression. Both demonstrated significant clinical efficacy, with improved pain and functional incapacity scores, as well as low blood loss volume and reduced surgical time. In addition, these techniques are associated with a low rate of complications per patient.

However, given the high heterogeneity of the available studies and the predominance of retrospective research, it becomes necessary to develop future analyses with greater methodological rigor. Prospective and randomized studies may contribute to a more accurate understanding of the advantages and limitations of subsequent endoscopic techniques in the treatment of cervical degenerative diseases.

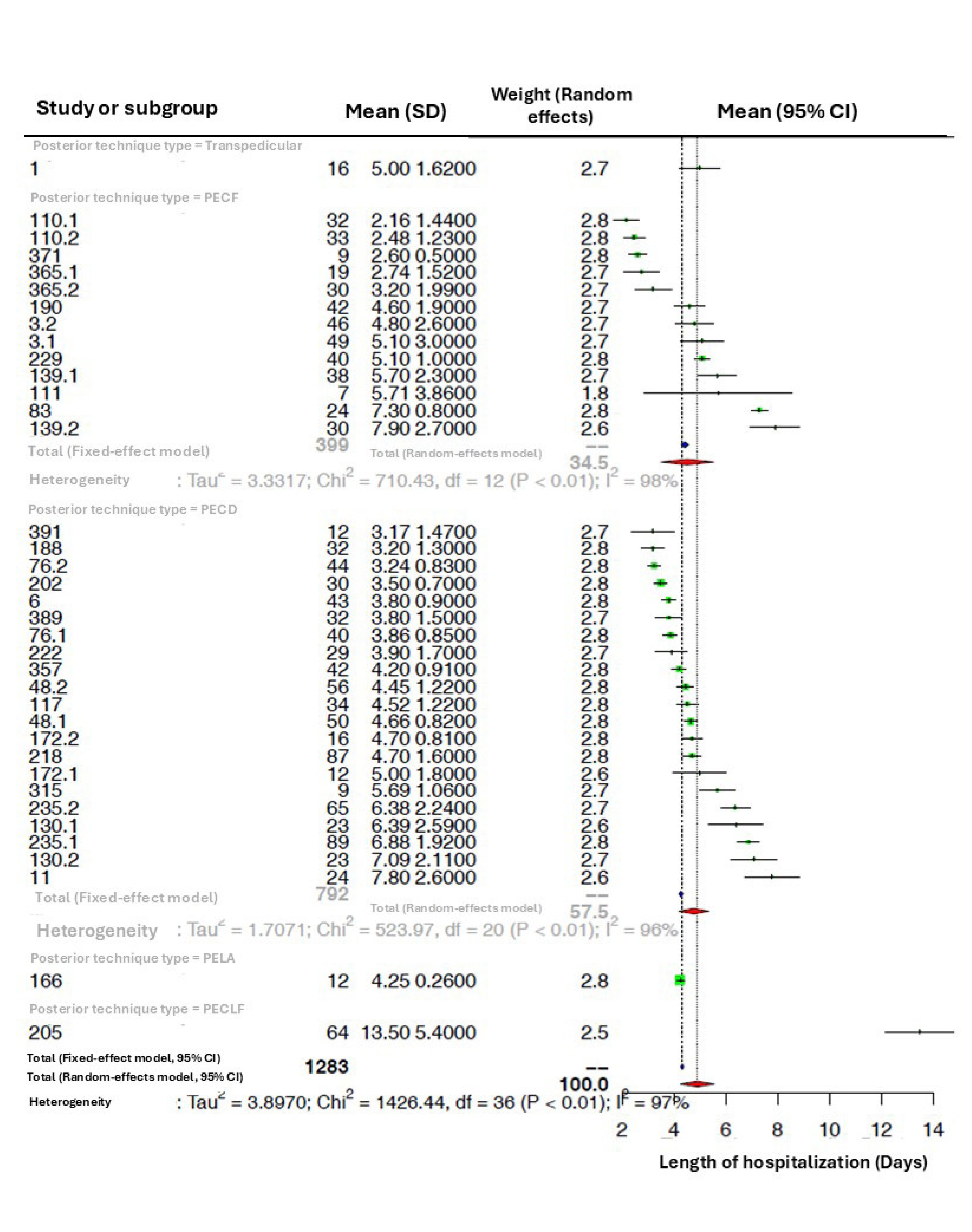

Figure 4. Estimated hospitalization time based on 37 studies included. The high heterogeneity (I2 = 97.5%) justified the use of the random effects model, resulting in an average of 5 days (95% CI: 4.2–5.5). Patients undergoing the PCLF technique presented higher hospitalization times compared to other surgical approaches.

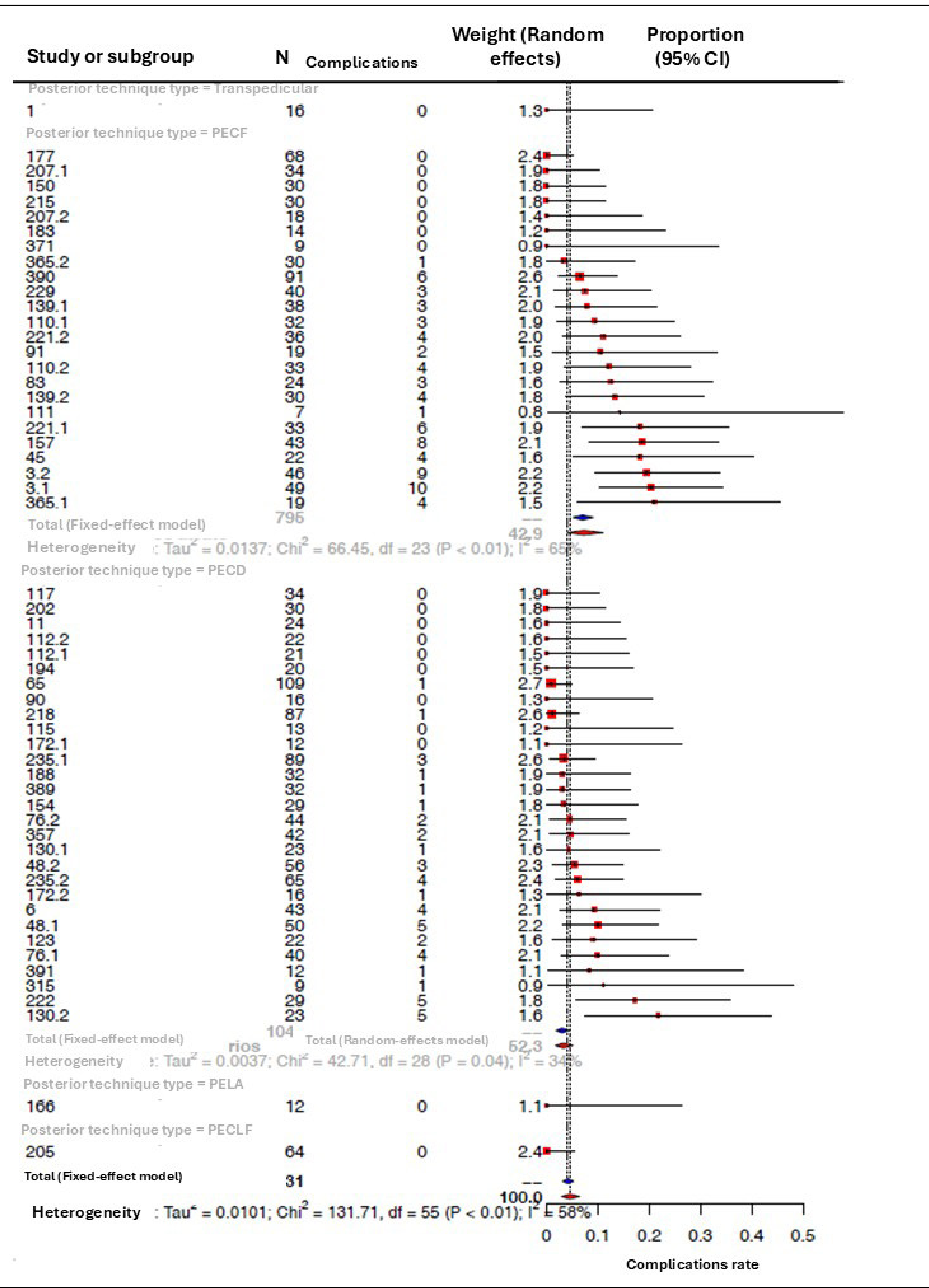

Figure 5. Meta-analysis of proportions on the occurrence of complications, with 56 studies included. The heterogeneity was considered significant (I2 = 58.2%), justifying the use of the model of random effects. The overall proportion of complications was 0.04 (95% CI: 0.029–0.064). The PECD technique demonstrated a protective effect in reducing the rate of complications compared to other approaches. Studies focused solely on the treatment of disc hernias showed lower proportions of complications.

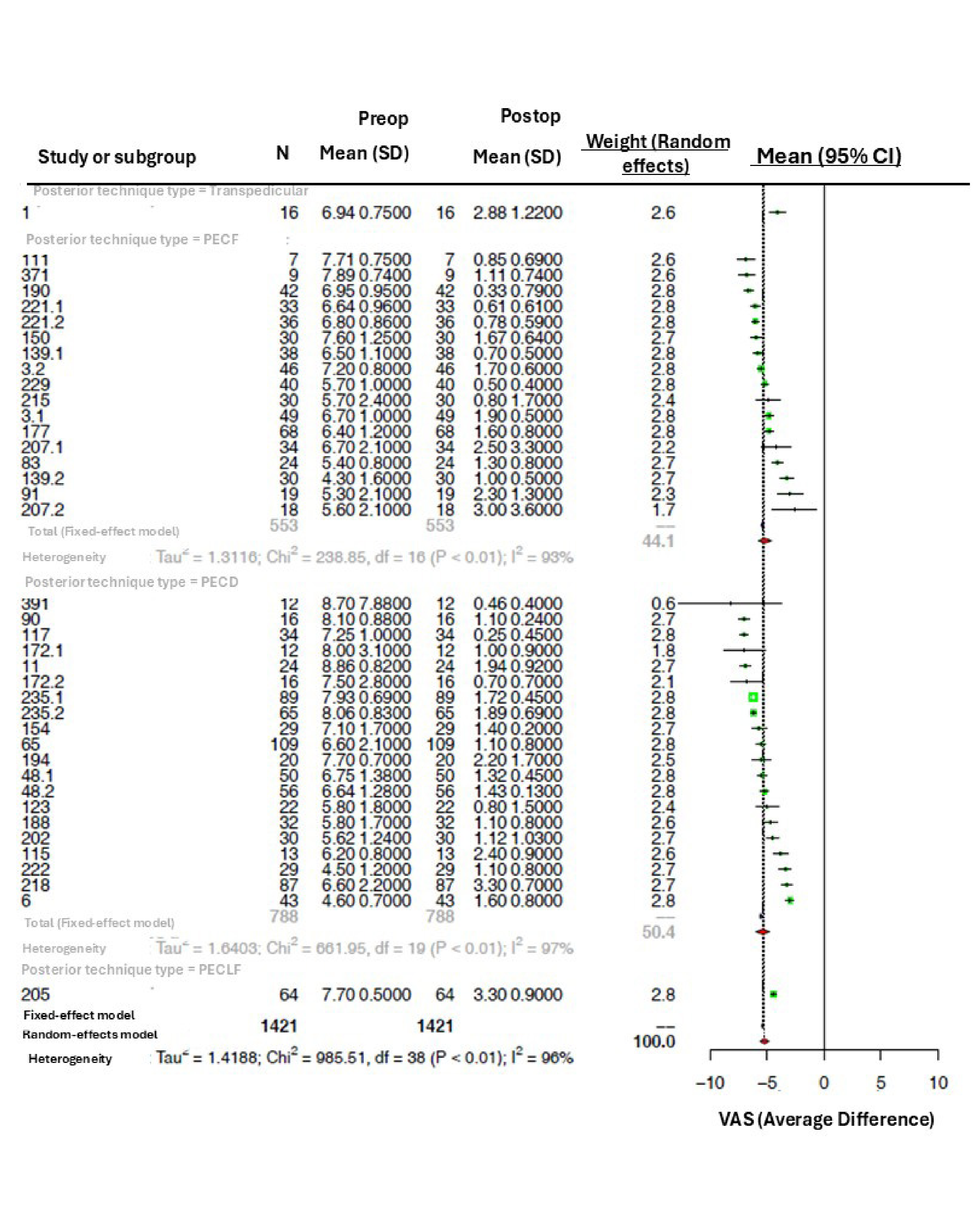

Figure 6. Analysis of the intensity of postoperative cervical pain based on 39 studies. The high heterogeneity (I2 = 96.2%) justified the use of the model of random effects. The mean difference between pre- and postoperative periods was -5.2 points on the analog visual scale (95% CI: -5.6 to -4.8), indicating significant improvement in cervical pain after the procedure.

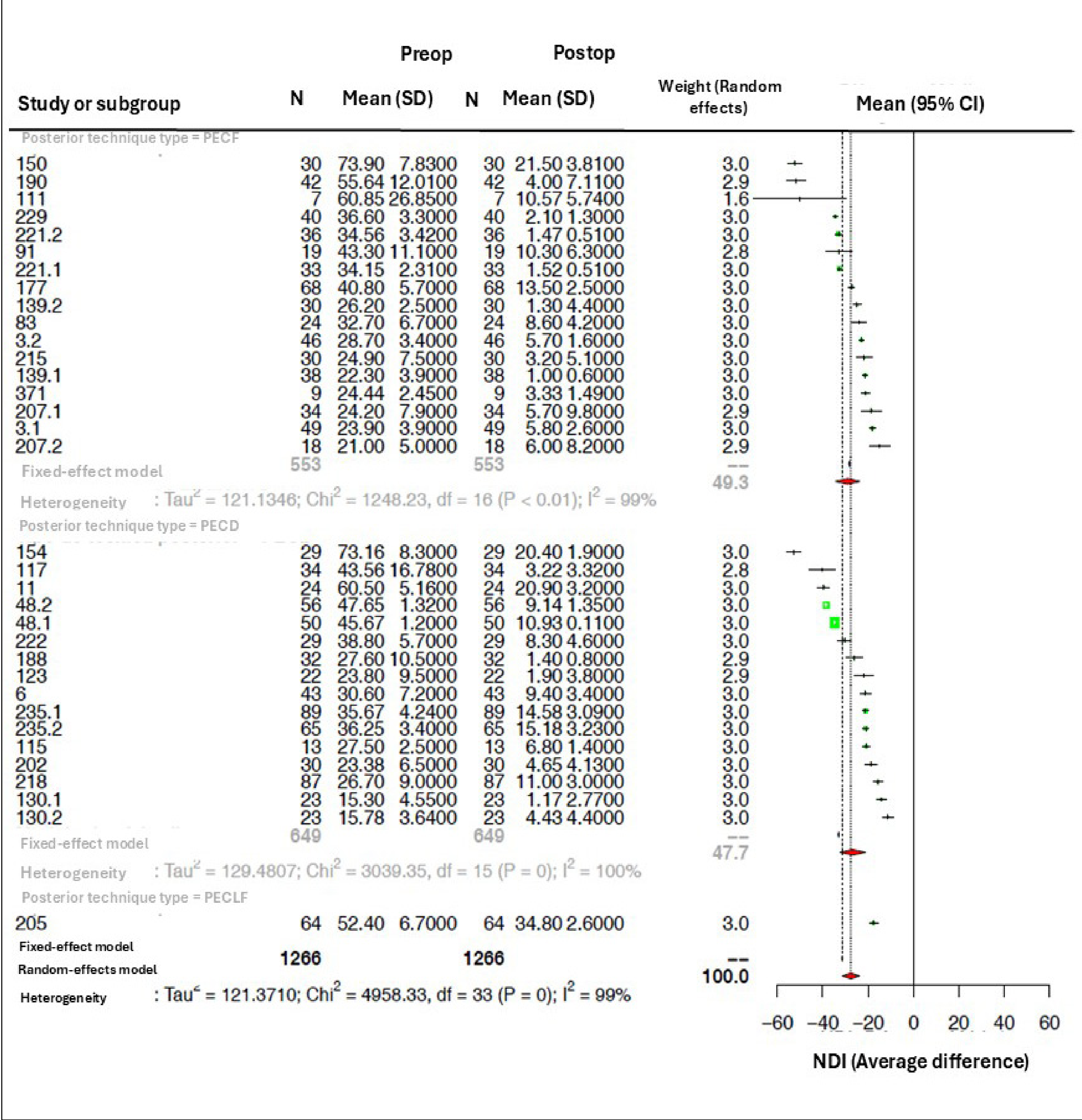

Figure 7. Analysis of functional disability score by the Neck Disability Index (NDI), with 34 studies included. The high heterogeneity (I2 = 99%) justified the use of the model of random effects. The average difference between pre- and postoperative periods was -27.5% (95% CI: -31.3% to -21.2%), indicating a significant functional improvement. No statistically significant differences were observed in the reduction of NDI between the evaluated surgical techniques.

Table 2. Summary of the analyses and patients included in each of them.

Variable	Number of entries	Number of Patients	Effect (unit)	Confidence interval
Time of surgery	44	1536	76 (min)	70.4 – 81.5
Blood loss	15	646	42 (mL)	31.4 – 51.1
Hospitality time	37	1283	5 (days)	4.2 – 5.5
Complications	56	1931	0.04 (/1000)	0.029 – 0.064
VAS Cervical	39	1421	-5.2 (points)	-5.6 - -4.8
NDI	34	1266	-27.5 (%)	-31.3 – -21.2

CONFLICT OF INTEREST

All authors declare no potential conflict of interest related to this article.

CONTRIBUTIONS OF THE AUTHORS

Each author contributed individually and significantly to the development of this article. LMAH, ALRL, DSAS, JLGF, VSP: conceptualization, methodology, data curation, writing - original draft; KOT, FFA, ETU, RRA, WFJ, AAAJ, SSS, CTF, JHM: formal analysis, validation; SEL and JPMB: writing - review and editing.

DATA AVAILABILITY DECLARATION

The contents underlying the research are available in the manuscript.

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