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REVIEW ARTICLE

Effects of chewing gum on gastrointestinal function in patients following spinal surgery: a meta-analysis and systematic review

Xiao-qin Liao[1] · Sai-lan Li[1] · Yan-chun Peng[1] · Liang-wan Chen[1] · Yan-juan Lin[1]

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Abstract

Purpose There are conflicting opinions regarding the efficacy of chewing gum for the recovery of gastrointestinal function in patients following spinal surgery. Thus, we aimed to conduct a systematic review and meta-analysis of existing articles to evaluate the effect of gum-chewing on patients following spinal surgery.

Methods A computer search was used to identify randomised controlled trials (RCTs) involving gum-chewing from eight databases: Cochrane Library, PubMed, Embase, MEDLINE, Web of Science, China National Knowledge Infrastructure, China Science and Technology Journal Database, and WanFang Data. After evaluating the risk of bias for the included studies, we used the Revman 5.3 software to conduct a meta-analysis of the data.

Results The study included seven RCTs, with a total of 706 patients. The meta-analysis reported that gum-chewing could shorten the interval between surgery and first bowel movement (mean deviation [MD] = −23.02; 95% confidence interval [CI]: −24.67, −21.38; $P < 0.00001$), first flatus (MD = −1.54; 95% CI −2.48, −0.60; $P = 0.001$), and first bowel sounds (MD = −5.08; 95% CI −6.02, −4.15; $P < 0.00001$). Moreover, there was a significant reduction in postoperative analgesic dosage within 12 h (standardised mean difference [SMD] = −0.28; 95% CI −0.52, −0.05; $P = 0.02$). However, there were no significant differences between the chewing gum and control groups ($P > 0.05$) regarding the postoperative nausea score, abdominal pain score, 24- and 48-h analgesic drug dosage, and length of hospital stay.

Conclusion To a certain extent, masticating gum can promote the recovery of gastrointestinal function and reduce the need for postoperative analgesics in patients following spinal surgery. However, this conclusion is affected by the quantity and quality of the included articles. Therefore, additional high-quality studies are needed to verify these results.

Keywords Chewing gum · Spine · Gastrointestinal function · Meta-analysis

Introduction

Gastrointestinal dysfunction following spinal surgery occurs in approximately 2.6–36.5% of patients [1–3] and manifests as abdominal distension, constipation, nausea, and vomiting. The dysfunction is mainly attributed to the prone positioning of the patient during surgery. The prone position activates the sympathetic nervous system, affecting the gastrointestinal motility of postoperative patients [2]. This complication seriously affects the intake and absorption of nutrients, delays postoperative recovery, prolongs hospital stay, and reduces patients' quality of life [4]. Currently, the treatment for gastrointestinal dysfunction includes pharmacotherapy and alternative therapies. Pharmaceutical interventions are not only expensive, but also induce side effects such as diarrhoea or, in long-term use patients, worsening of constipation [5, 6]. Non-pharmaceutical interventions mainly include

Xiao-qin Liao and Yan-juan Lin have the same contribution to this research and share first authorship.

✉ Liang-wan Chen
chenliangwan@tom.com

✉ Yan-juan Lin
fjxhyjl@163.com

Xiao-qin Liao
17850858308@163.com

Sai-lan Li
672726516@qq.com

Yan-chun Peng
1078494566@qq.com

[1] Fujian Medical University Union Hospital, Fuzhou 350001, Fujian, People's Republic of China

#1·chewing·gum·OR·sham·feeding·OR·gum·chewing·↵

#2·Vertebral·Column·OR·Spinal·Columns·OR·Spinal·Column·↵

#3· randomized· controlled· trial· OR· randomized· controlled· study· OR randomized·controlled·clinical·trial·OR·RCT·↵

#4·#1·AND·#2·AND·#3↵

RCT=randomised clinical trial

Fig. 1 PubMed search strategy. RCT = randomised clinical trial

acupuncture, massage, and moxibustion [7–9] and require greater staffing and are usually challenging to implement in clinical practice. Gum mastication is one way to false feed. False feeding promotes gastric vagus nerve reflex excitement, increases intestinal peristalsis, promotes exhaust and excretion, and accelerates the recovery of gastrointestinal function in patients following surgery [10]. Studies have confirmed [11, 12] that gum-chewing can promote the recovery of gastrointestinal function in patients after abdominal surgery. However, few studies have reported the effect of chewing gum on patients' gastrointestinal function after spinal surgery, and the results of these studies vary. Some researchers believe that gum-chewing does not promote the recovery of gastrointestinal function in patients who have undergone spinal surgery [13–15], while others believe gum-chewing may improve gastrointestinal function [16–19]. Therefore, this study aimed to conduct a meta-analysis of existing related articles to evaluate the effect of gum-chewing on patients following spinal surgery.

Methods

Search strategy

This meta-analysis was planned, executed, and reported following the standards set by the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines [20, 21]. This study has been registered on the Systematic Reviews website (Registration number: CRD42021281805). We conducted a computer search on eight databases: Cochrane Library, PubMed, Embase, MEDLINE, Web of Science, China National Knowledge Infrastructure (CNKI), China Science and Technology Journal Database (VIP), and Wan-Fang Data. The time frame for the search was set from the establishment of the database to September 2021. The search terms included chewing gum, gum-chewing, sham feeding, vertebral column, and spinal column/s. Finally, the search scope was further expanded by reading the references included in each literature search (Fig. 1).

Inclusion and exclusion criteria

Any literature that met the following criteria was included: 1. The study was a randomised controlled trial (RCT); 2. The population included patients who underwent spinal (cervical, thoracic, lumbar) surgery; 3. The control group was treated with routine interventions, and the experimental group used chewing gum to promote gastrointestinal peristalsis; 4. Outcome indicators included one or more of the following: time to first bowel movement, time to first exhaust, time to first bowel sounds, nausea score, abdominal pain score, analgesic dose, and length of hospital stay. Patient race, nationality, and course of illness were not limited. The following literature was excluded: 1. non-Chinese and English literature; 2. duplicate publications; 3. literature from which complete data could not be obtained; 4. literature with unreasonable research design.

Data abstraction

In this study, two reviewers independently conducted literature screening and data extraction. Literature screening verified that the studies met the inclusion and exclusion criteria. Data extraction was based on a pre-set data feature table (including author, publication year, country, sample size, intervention measures, and outcome indicators). If the two reviewers could not reach a consensus during the literature screening and data extraction process, a third reviewer would make the assessment and final decision.

Bias risk assessment

Two reviewers evaluated the quality of the literature included in this study according to the evaluation criteria specified by the Cochrane Style Manual. The evaluation criteria consist of seven items, namely the generation of random sequences, hiding of the random schemes allocation, blinding of the research subjects and their interventions, blinding of the result assessors, completeness of the outcome index data, the possibility of selective reporting bias, and other biases. The evaluators made judgements concerning the degree of bias risk based on the quality of the literature. Finally, the two evaluators checked the literature bias risk assessment. Any differences in evaluation opinions were consulted with a third evaluator to reach a unified opinion.

Statistical analysis

RevMan (version 5.3) software was used to analyse the data in this study. Binary data were analysed by odds ratio. If continuous data had the same outcome indicator measurement tool, the mean difference (MD) was used for analysis.

If the outcome indicator measurement tool was different, or the measured results were too different, the standardised mean difference (SMD) was used for analysis. The confidence interval is expressed as 95% CI. The studies were homogeneous if $P > 0.1$ or $I^2 < 50\%$ but a $P \leq 0.1$ or $I^2 \geq 502\%$ indicated heterogeneity between the studies. The fixed-effects model was used to analyse these data. Subgroup analysis or sensitivity was used to determine the source of the heterogeneity. The random-effects model was used to analyse the data if the heterogeneity origin was not ascertained. If a certain outcome index was included in more than seven articles, a bias analysis was performed to determine whether there was publication bias.

Results

Literature search results

A total of 483 articles were retrieved, 265 duplicate articles were eliminated by NoteExpress, and 181 were eliminated after reading the title and abstract. A total of 37 articles entered the final full-text reading and screening stage. After rigorous screening, the study finally included seven RCTs [13–19] for meta-analysis (Fig. 2).

Characteristics of included studies

The seven studies in this meta-analysis were published from 2015 to 2021 in China, Malaysia, and the USA. There were 706 patients with 351 patients in the intervention group and 355 in the control group (Table 1).

Results of literature bias risk assessment

The seven articles included in this study are of medium quality. Six documents mentioned random allocation schemes, and three papers mentioned blinding. The baseline data of all documents are comparable (Fig. 3).

Time to first bowel movement

Seven articles reported the time of the patients' first bowel movement following spinal surgery. Due to the high degree of heterogeneity between the studies ($P < 0.00001$, $I^2 = 97\%$), we conducted a subgroup analysis. The heterogeneity of the adolescent group was significantly reduced ($P = 0.32$, $I^2 = 14\%$). Based on the fixed-effects model, the meta-analysis showed that chewing gum could not shorten the interval to the first defecation in adolescent patients (MD = − 0.14; 95% CI − 0.35, 0.07; $P = 0.18$). The heterogeneity of the middle-aged and elderly group was relatively high ($P < 0.00001$, $I^2 = 98\%$). Using sensitivity analysis to eliminate selected documents one by one, we found that the study by Dian [18] was the primary source of heterogeneity for the middle-aged and elderly groups. After excluding the study by Dian [18], the heterogeneity was reduced ($P = 0.32$, $I^2 = 14\%$). The fixed-effects model was used for the analysis. The results showed that before and after sensitivity analysis, the results did not significantly change and were relatively stable, indicating

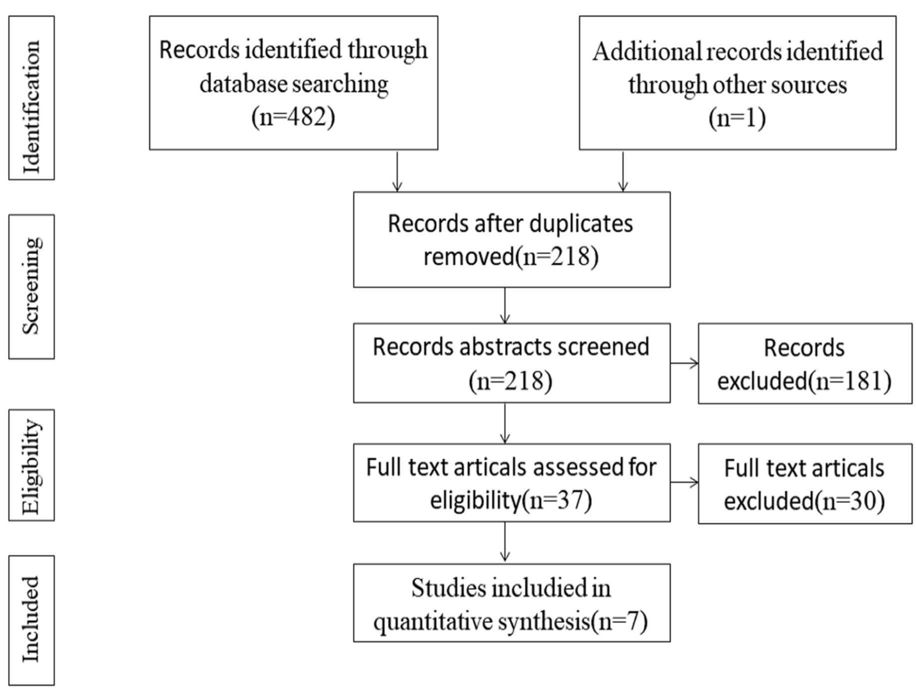

Fig. 2 Flow diagram of literature inclusion

Table 1 Characteristics of the seven studies included in this systematic review

Studies	Year	Country	Sample size		Mean age (Years)		Interventions		Outcome measures
			T	C	T	C	T	C	
Chan [13]	2017	Malaysia	30	30	16.7 ± 6.1	16.4 ± 5.4	From 2 h to 3 days postoperatively, patients chewed the gum for approximately 30 min every 4–6 h	Routine treatment and nursing	①②④⑤⑥
Du [16]	2021	China	30	30	66.4 ± 3.4	67.1 ± 4.3	The patients began to chew gum 4 h after waking from anaesthesia for at least 15 min once every hour. After the first anal exhaustion, the patients chewed gum every 8 h until the first bowel movement	Routine treatment and nursing	①②③⑥
Jennings [17]	2015	USA	42	41	14.5 ± 1.1	14.3 ± 2.1	Gum-chewing was done five times a day for 15–30 min, starting on the first postoperative day	Routine treatment and nursing	①②⑤⑥
Meng [14]	2018	China	63	62	12.8 ± 1.8	13.3 ± 2.1	Patients chewed gum for 20–30 min from the first to the third postoperative day at 8:00, 12:00, and 18:00	Routine treatment and nursing	①②④⑤⑥
Dian [18]	2019	China	107	107	56.63 ± 10.53	54.78 ± 11.78	After waking from anaesthesia, the patients were given chewing gum, two doses each time, four times a day (8:00, 11:00, 17:00, 21:00), chewing for 10–15 min each time until the seventh postoperative day	Routine treatment and nursing	①
Hua [15]	2018	China	50	50	13.1 ± 2.0	12.9 ± 2.4	Patients chewed gum for 20–30 min from the first to the third postoperative day at 8:00, 12:00, and 18:00	Routine treatment and nursing	①②④⑤⑥
Du [19]	2018	China	30	35	50.23 ± 10.11	50.14 ± 11.38	The patients were fully awake 6 h after anaesthesia and started chewing gum, two doses each time, once every 4 h for at least 15 min. After the first gas was exhausted from the anus, chewing was changed to once every 8 h and stopped on the fifth postoperative day	Routine treatment and nursing	①②③⑥

T = chewing gum group; C = control group; ① = first defecation; ② = first exhaust; ③ = first bowel sounds; ④ = analgesic dosage; ⑤ = nausea score; ⑥ = length of hospital stay

that chewing gum may shorten the interval to the first bowel movement for middle-aged and elderly patients (MD = – 23.59; 95% CI – 25.27, – 21.92; $P < 0.00001$). The final combined effect size showed that chewing gum might promote a shorter time to the first bowel movements following spinal surgery (MD = – 23.02; 95% CI – 24.67, – 21.38; $P < 0.00001$) (Fig. 4).

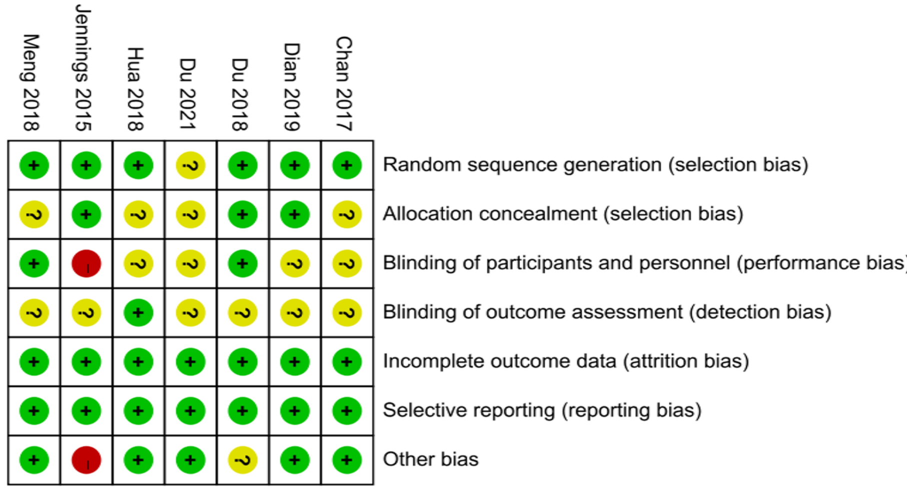

Fig. 3 Assessment of risk of bias of the included studies

First exhaust time

Six articles reported the interval to the patients' first exhaust. There was heterogeneity between these studies ($P = 0.0002$, $I^2 = 80\%$). Still, neither subgroup analysis nor sensitivity analysis reduced the heterogeneity between the studies, so we selected a random-effects model to merge the data. The analysis results showed that compared with conventional nursing interventions, chewing gum could reduce the interval to the first exhaust (MD = − 3.65; 95% CI − 6.80, − 0.51; $P = 0.02$) (Fig. 5).

First bowel sounds

Two articles reported the interval to first bowel sounds after gum-chewing. The heterogeneity between studies was low ($P = 0.50$, $I^2 = 0\%$), and the fixed-effects model was chosen. Meta-analysis results showed that compared with conventional care, chewing gum significantly promotes intestinal peristalsis, indicating that it could promote the recovery of patients' intestinal function (MD = − 5.08; 95% CI − 6.02, − 4.15; $P < 0.00001$) (Fig. 6).

Postoperative nausea score

Four articles reported the nausea scores of patients at 24 h and 48 h postoperatively. The heterogeneity of the nausea score at both 24 h and 48 h postoperatively was low ($P = 0.82$, $I^2 = 0\%$ and $P = 0.92$, $I^2 = 0\%$, respectively). The fixed-effects model was selected for both measures. Meta-analysis results showed that compared with conventional care, chewing gum did not reduce the nausea score at 24 h (MD = 0.21; 95% CI − 0.24, 0.67; $P = 0.35$) or at 48 h (MD = 0.01; 95% CI − 0.34, 0.36; $P = 0.95$) postoperatively (Fig. 7).

Postoperative abdominal pain score

Three articles reported the patients' 24-h and 48-h postoperative abdominal pain scores. The heterogeneity of the abdominal pain scores at 24 h and 48 h postoperatively was low ($P = 0.29$, $I^2 = 19\%$ and $P = 0.51$, $I^2 = 0\%$, respectively). The fixed-effects model was selected for both measures. Meta-analysis results showed that compared with conventional care, chewing gum could non-significantly reduce the abdominal pain score at 24 h postoperatively (MD = − 0.50; 95% CI − 1.04, 0.03; $P = 0.07$) but did not reduce the abdominal pain score at 48 h postoperatively (MD = − 0.05; 95% CI − 0.57, 0.46; $P = 0.84$) (Fig. 8).

Postoperative analgesic drug dosage

Three articles reported analgesic dosages for patients at 12 h, 24 h, and 48 h postoperatively. The heterogeneity of the analgesic dosage requirement 12 h postoperatively was low ($P = 0.33$, $I^2 = 9\%$), and the fixed-effects model was selected. Meta-analysis results showed that chewing gum could reduce analgesic use in patients after 12 h (SMD = − 0.28; 95% CI − 0.52, − 0.05; $P = 0.02$). There was heterogeneity in the analgesic dosages at 24 h postoperatively ($P = 0.02$, $I^2 = 76\%$). After sensitivity analysis and excluding the literature by Hua [15], no significant changes were seen in the meta-analysis results ($P > 0.05$). The results were relatively stable, indicating that chewing gum could not reduce analgesic dosage at 24 h postoperatively (MD = − 0.17; 95% CI − 0.46, 0.12; $P = 0.24$). The heterogeneity of the analgesic dosages at 48 h postoperatively was low ($P = 0.86$, $I^2 = 0\%$). The fixed-effects model was selected. The results showed that chewing gum could not reduce analgesic dosages at

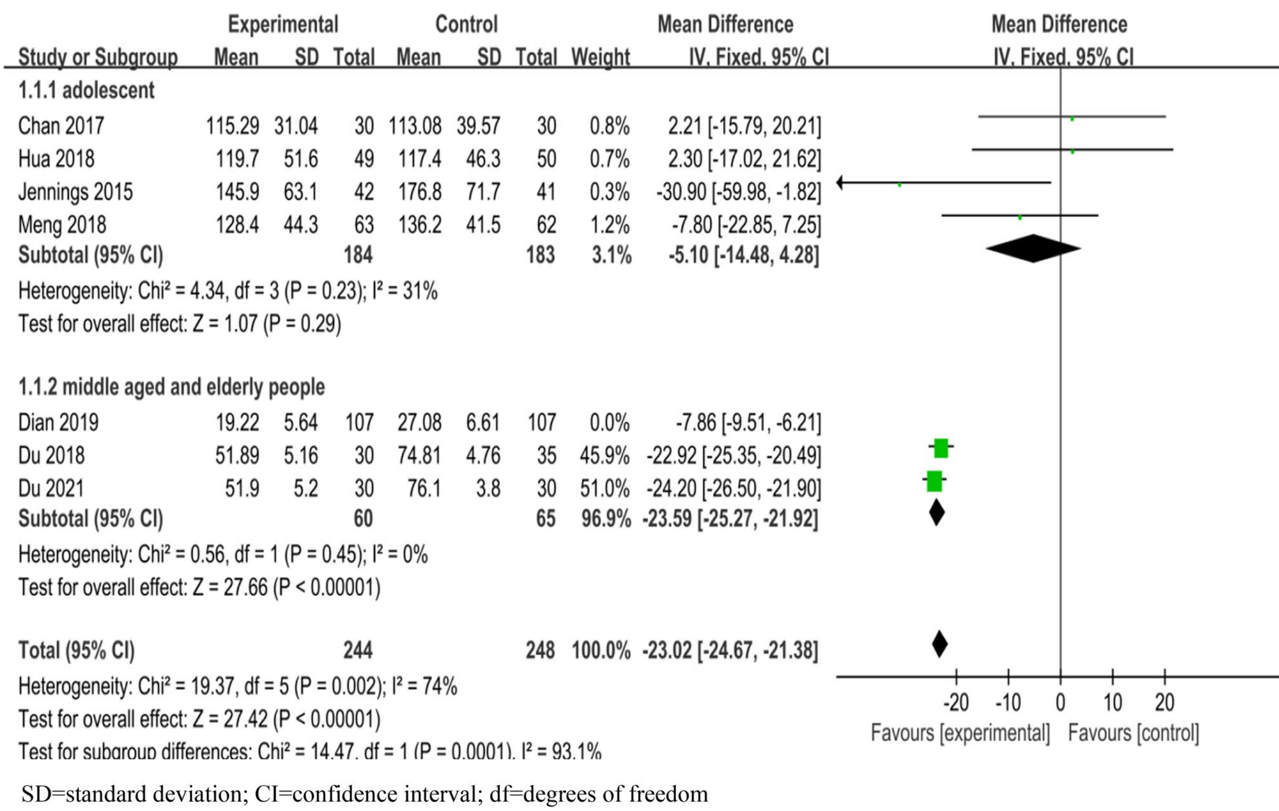

Fig. 4 Forest diagram of the first bowel movement time. SD = standard deviation; CI = confidence interval; df = degrees of freedom

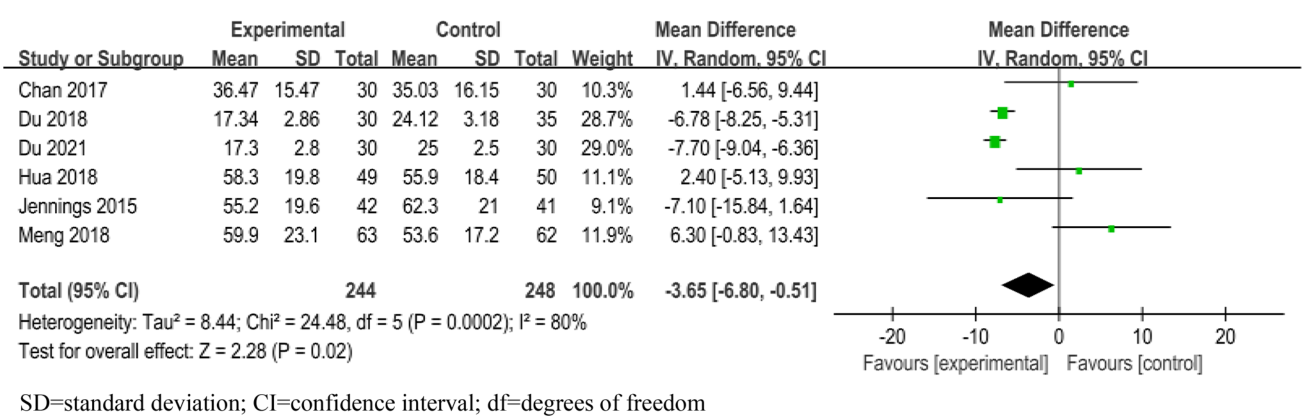

Fig. 5 Forest diagram of the first exhaust time. SD = standard deviation; CI = confidence interval; df = degrees of freedom

48 h postoperatively (MD = −0.17; 95% CI −0.40, 0.06; $P = 0.15$) (Fig. 9).

Hospital stay

Six articles reported the patients' length of hospital stay. Due to the low heterogeneity between studies ($P = 0.39$, $I^2 = 4\%$), the fixed-effects model was selected to analyse the data. Meta-analysis results showed that compared with conventional care, chewing gum did not reduce the patient's hospital stay (MD = 0.04; 95% CI −0.13, 0.22; $P = 0.64$) (Fig. 10).

Publication bias analysis

The funnel chart shows that most of the included studies are concentrated in the upper-middle section. The studies on

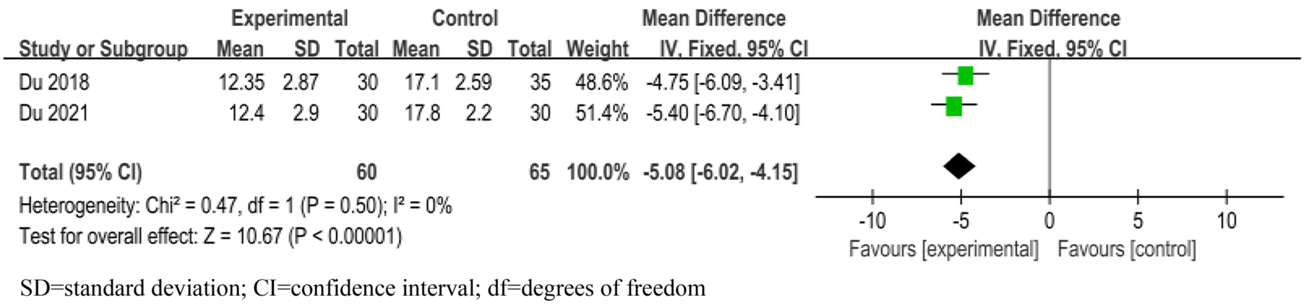

Fig. 6 First bowel sounds forest map. SD = standard deviation; CI = confidence interval; df = degrees of freedom

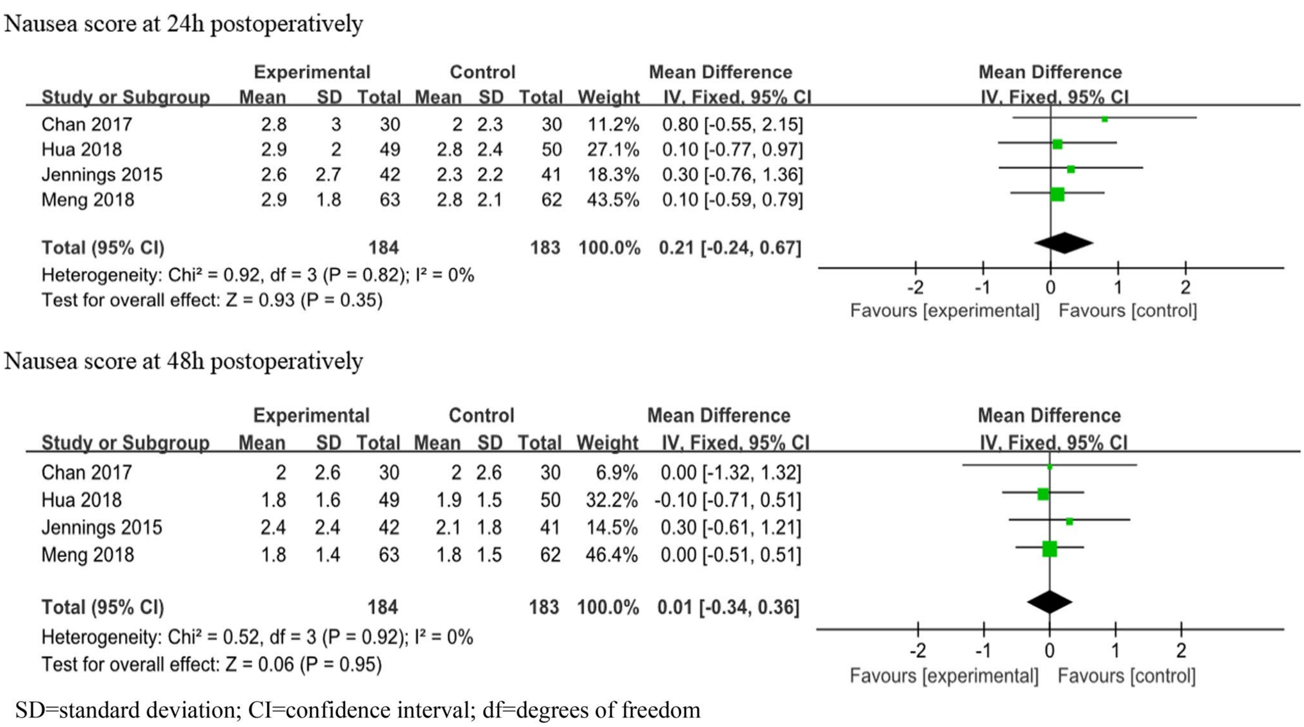

Fig. 7 Postoperative nausea score forest plot. SD = standard deviation; CI = confidence interval; df = degrees of freedom

both sides of the funnel chart are asymmetrical, indicating a bias between the studies (Fig. 11).

Discussion

Vomiting and enteroparalysis are the two most common gastrointestinal symptoms in patients following spinal surgery [22]. Relevant studies have shown [12, 23, 24] that gum-chewing positively impacts the recovery of gastrointestinal function in patients after abdominal surgery, caesarean section, and rectal surgery. This meta-analysis also shows that compared with conventional care, gum-chewing can promote the recovery of gastrointestinal function in patients after spinal surgery to a certain extent. The subgroup analysis of the first bowel movement showed that chewing gum could significantly shorten the interval to the first bowel movement in middle-aged and elderly patients. However, the effect on the interval to the first bowel movement in adolescents was statistically insignificant. Relevant studies have shown [10, 25] that gum-chewing can promote the recovery of gastrointestinal function for two reasons. First, gum-chewing simulates food intake, causing physiological intestinal irritation and promoting gastric acid and pepsinogen secretion. In addition, the secretion of gastrointestinal hormones such as motilin promotes gastrointestinal motility. Second, mastication stimulates nerve function, increases the release of

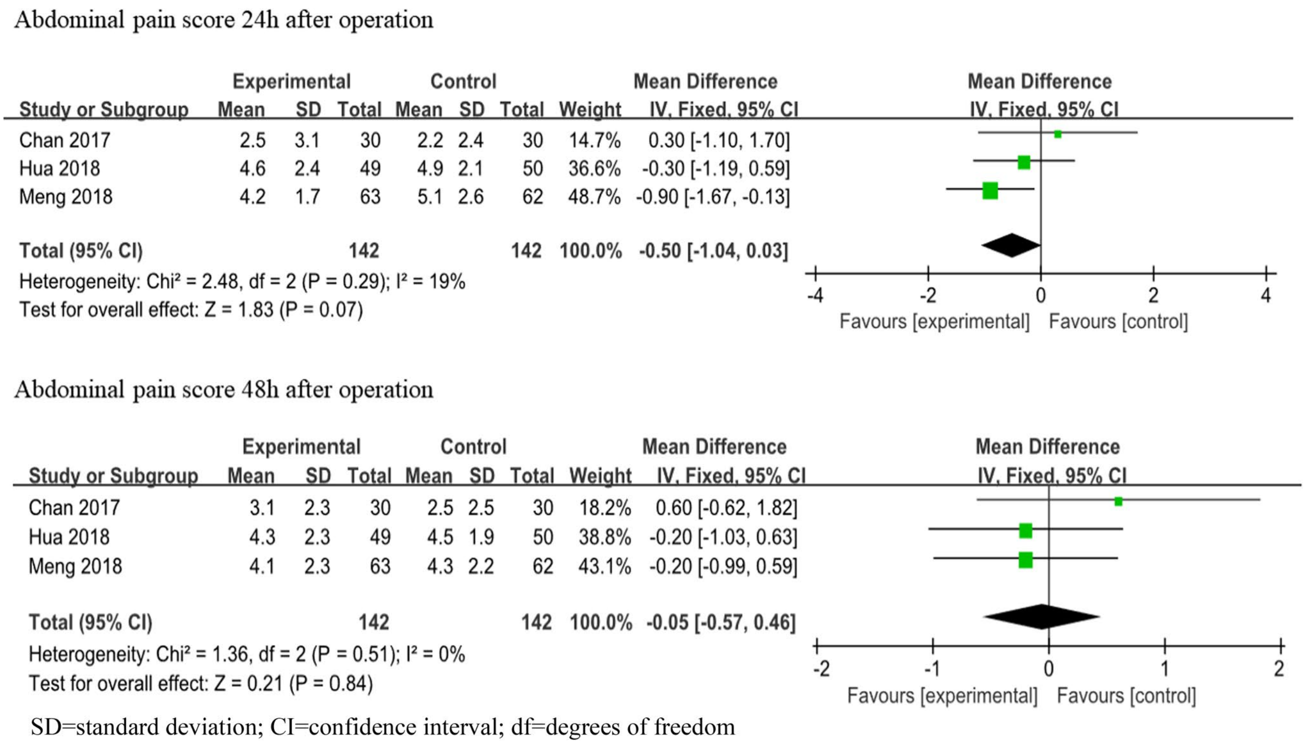

Fig. 8 Postoperative abdominal pain score forest plot. SD = standard deviation; CI = confidence interval; df = degrees of freedom

acetylcholine, and reduces the release of pro-inflammatory factors, promoting the recovery of gastrointestinal function.

Van den Heijkant et al. [26] found that chewing gum can significantly relieve postoperative pain and reduce the analgesic requirement. Yildizeli Topcu et al. [27] reported that chewing gum could reduce pain and proposed that it can be utilised in postoperative patient care. This study also showed that chewing gum alleviates postoperative pain in patients. In addition, chewing gum can reduce analgesic use in patients within 12 h postoperatively ($P < 0.05$). However, the effect of chewing gum on analgesic use at 24 h and 48 h was statistically insignificant ($P > 0.05$). This may be related to the changes in local wound pain following the operation. The study by Kang et al. [28] revealed that the pain on the incision site in patients after spinal surgery was the most obvious within 12 h postoperatively, with patients reporting the highest pain scores during this period, which gradually decreased. The demand for analgesic requirement by patients was positively correlated with the pain score. The dose of analgesics was significantly higher within 12 h postoperatively and decreased over time. Therefore, we speculate that gum-chewing within 12 h after spinal surgery can significantly relieve pain.

The meta-analysis by Liu [29] showed that chewing gum could shorten patients' hospital stay after abdominal surgery. However, this study did not reach the same conclusion. Our meta-analysis showed that gum-chewing could not significantly reduce patient hospital stay compared with conventional care ($P > 0.05$). Due to the small sample size of the included seven articles, the results may vary with additional participants. Therefore, further analysis is needed to confirm the effect of chewing gum on the length of hospital stay.

The study's bias analysis funnel chart identified publication bias among the studies. The seven articles we included were all small-sample, single-centre, medium-quality studies, and the intervention programmes had varying degrees of defects. First, a lack of blinding methods in research can easily lead to the Hawthorne effect. Second, the lack of more scientific measurement methods for collecting outcome indicators may have caused bias, such as in the case of first exhaust time. Postoperative patients often ignore their own first exhaust time due to factors such as wound pain and tension, resulting in inaccurate records of the patient's first exhaust time. Finally, there were differences in the intervention programmes and gum-chewing duration, which may also add to the disparities of the final results. In future research, it is necessary to increase the implementation of blinding, determine the optimal frequency and duration of gum-chewing for patients, explore more scientific intervention programmes, and conduct many local, multi-centre, high-quality studies.

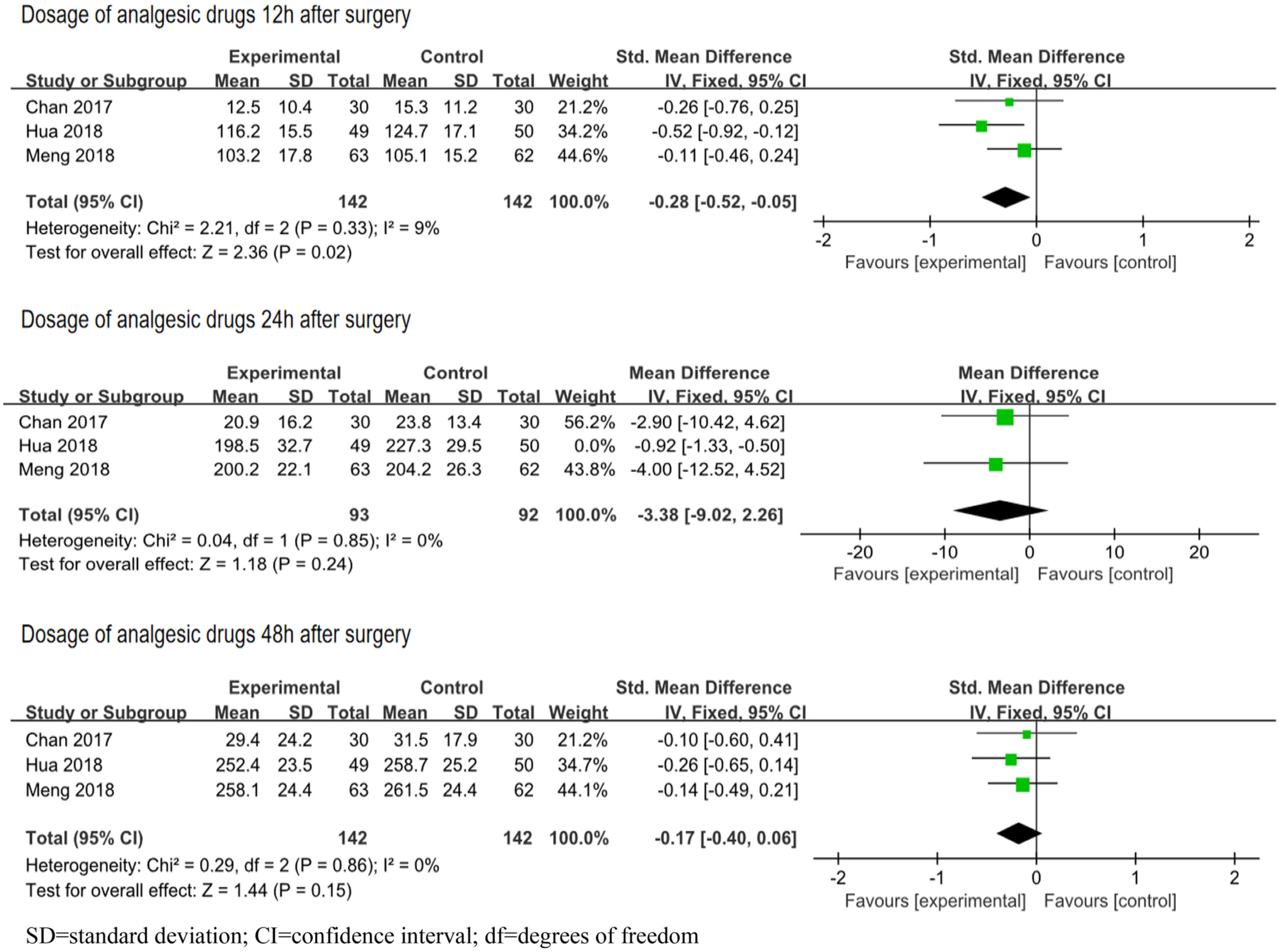

Fig. 9 Forest diagram of postoperative analgesic drug consumption. SD = standard deviation; CI = confidence interval; df = degrees of freedom

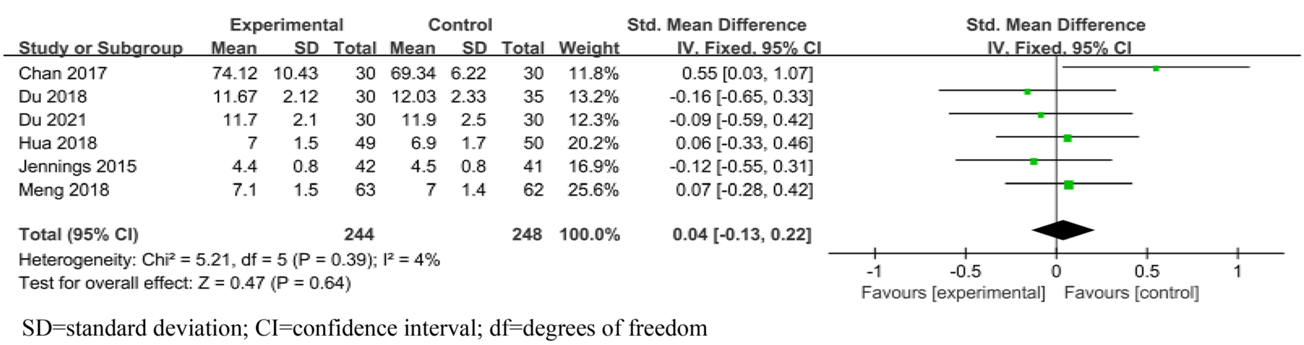

Fig. 10 Forest diagram of hospitalisation time. SD = standard deviation; CI = confidence interval; df = degrees of freedom

Conclusion

This meta-analysis showed that chewing gum positively affects the recovery of gastrointestinal function in patients following spinal surgery. In addition, gum-chewing reduces analgesic drug use within 12 h postoperatively. However, it had no effect in reducing the nausea score, abdominal pain score, length of hospital stay, and analgesic use at 24 h and 48 h postoperatively.

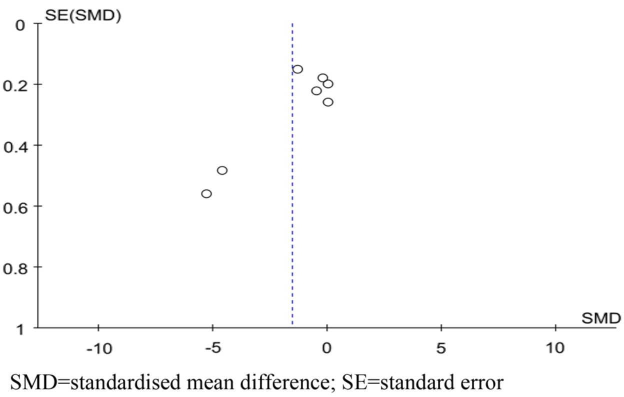

Fig. 11 Funnel chart of bias analysis. SMD = standardised mean difference; SE = standard error

Author contributions Xiao-qin Liao and Yan-juan Lin are mainly responsible for planning, document screening, data extraction, statistical analysis, and the initial drafting of the manuscript. Sai-lan Li and Yan-chun Peng participated in data extraction and literature quality evaluation. Yan-juan Lin and Liang-wan Chen reviewed the first draft and prepared the final draft of the manuscript. Finally, all authors read and approved the final draft of the manuscript.

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Declarations

Conflict of interest The authors declare that they have no competing interests.

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