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Early oral feeding after laparoscopic total gastrectomy in gastric cancer patients: a meta-analysis of randomized controlled trials and cohort studies

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Abstract

Background Gastric cancer remains a leading cause of cancer-related morbidity and mortality worldwide, with surgery being central to treatment. However, postoperative malnutrition is common and significantly impairs recovery. Early oral feeding (EOF) has been proposed as a strategy to promote gastrointestinal recovery and reduce complications, but its clinical effectiveness following gastrectomy remains uncertain.

Methods A systematic review and meta-analysis were conducted according to PRISMA guidelines. Studies comparing EOF with delayed oral feeding (TOF) in gastric cancer patients were included. Outcomes assessed were hospital stay, time to first anal exhaust, postoperative complications, feeding tolerance, and serum albumin and prealbumin levels. Data were pooled using random-effects models, and evidence certainty was evaluated using the GRADE approach.

Results Fifteen studies (1,847 patients) were included. EOF significantly reduced hospital stay (–1.82 days) and time to first anal exhaust (–0.85 days), and improved albumin and prealbumin levels. No significant differences were found in postoperative complications or feeding intolerance. Subgroup analyses demonstrated consistent findings across surgical techniques, extent of gastrectomy, ERAS protocol implementation, and study design. Overall, the certainty of evidence was rated as very low due to concerns regarding risk of bias, heterogeneity, and imprecision.

Conclusion EOF is a safe and effective approach after gastrectomy, promoting faster recovery without increasing complications. Further trials are needed to confirm its benefits and guide standardized protocols.

Keywords Early oral feeding, Gastric cancer, Gastrectomy, Postoperative care, Meta-analysis

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Introduction

Gastric cancer (GC) is the fifth most common cancer in terms of both incidence and mortality worldwide [1]. A combination of controllable and non-controllable risk factors contributes to its development. Controllable risk factors include obesity, poor diet and lifestyle, *Helicobacter pylori* (H. pylori) infection, alterations in gastrointestinal microbiota, tobacco and alcohol use, chemical exposure, radiation, and certain viral infections. Non-controllable factors include age, sex, ethnicity, and genetic predisposition. In addition, a history of gastric surgeries and gastrointestinal diseases such as gastric ulcers and gastroesophageal reflux disease may also play a role in the etiology of GC [2, 3].

Surgical intervention remains the cornerstone of treatment for GC, with common procedures including total gastrectomy (TG), subtotal gastrectomy (STG), distal gastrectomy (DG), pylorus-preserving gastrectomy (PPG), and proximal gastrectomy (PG) [4]. However, due to the fact that most patients are diagnosed at advanced stages, adjunct therapies such as chemotherapy, cellular immunotherapy, immune checkpoint inhibitors (ICIs), and cancer vaccines are often necessary to improve survival outcomes [5].

Malnutrition is a significant concern in GC patients, affecting approximately 60% of individuals pre- and postoperatively. Among surgical types, TG is associated with the most severe nutrition-related complications [6]. Malnutrition contributes to longer hospital stays, increased risk of infection-related complications, higher healthcare costs, and increased morbidity and mortality [7, 8].

Several nutritional strategies are used to manage feeding in patients after GC surgery. Enteral nutrition (EN) involves the delivery of nutrients via gastric or jejunal feeding tubes in liquid form. Parenteral nutrition (PN) refers to intravenous nutrient delivery, while oral nutrition supplements (ONS) provide additional calories and nutrients in liquid or powder form for patients unable to meet their nutritional needs through regular food intake [6]. The main routes for EN include nasogastric (NGT) and nasojejunal (NJT) tubes. However, their use may lead to complications such as gastric retention, intestinal obstruction, and delayed return to normal bowel function [9].

Oral feeding is considered a less invasive and more physiological approach that may enhance quality of life (QoL) following surgery. Nevertheless, it is often postponed until certain clinical signs, such as passage of flatus, audible bowel sounds, or bowel movements, indicate successful anastomotic healing. Recent studies, however, suggest that early oral feeding (EOF) is a safe and feasible strategy that may accelerate gastrointestinal recovery, maintain mucosal integrity, reduce catabolism and muscle wasting associated with prolonged fasting, shorten hospital stays, improve QoL, and lower postoperative morbidity [9–11].

Therefore, this meta-analysis aims to evaluate the impact of EOF on postoperative outcomes in patients with GC undergoing gastrectomy in randomized controlled trials and cohort studies.

Materials and methods

Search strategy

An extensive search was conducted to identify potentially eligible studies across various databases, including Scopus, Embase, PubMed, Web of Science, following the PRISMA guidelines up to January 2025 [12]. Table 1 illustrates the full search strategy.

Inclusion and exclusion criteria

The studies that met the following criteria were included in the meta-analysis: (1) observational studies and RCTs; (2) adult patients (≥ 18 years old); (3) gastric cancer patients who received oral feeding after gastrectomy; (5) data on outcomes including the length of hospitalization, time to first anal exhaust, postoperative complications, oral feeding tolerance, and levels of albumin and prealbumin; and (6) well-defined and suitable methods for oral feeding.

The exclusion criteria consisted of: (1) in vitro or animal studies, comments, case reports, letters, ongoing trials, protocols, and reviews; (2) studies lacking applicable data; (3) duplicates or overlapping participants; (4) unclear definitions of oral feeding methods.

Study selection

After removing duplicate publications, two reviewers (A.B. and C.D.) independently screened the remaining studies by title and abstract to identify potentially eligible articles. Full texts of the selected articles were then independently assessed by the same reviewers based on the predefined inclusion and exclusion criteria. In cases where there were disagreements during either stage, the reviewers first discussed the discrepancies to reach a consensus. If consensus could not be achieved, a third reviewer (E.F.) was consulted to adjudicate and make the final decision.

Data extraction

Two independent researchers (A.B. and C.D.) performed data extraction using a pre-designed data collection spreadsheet developed prior to the review process. Extracted data were categorized into three main areas: (1) study characteristics, (2) primary and secondary outcomes, and (3) methodological characteristics for quality assessment.

Study characteristics included: first author, year of publication, country, participant demographics (age and

Table 1 Search strategies and retrieved articles from databases

Database	Query	Retrieved articles
PubMed	(((carcin*[Title/Abstract] OR cancer*[Title/Abstract] OR neoplas*[Title/Abstract] OR tumour*[Title/Abstract] OR tumor*[Title/Abstract] OR cyst*[Title/Abstract] OR growth*[Title/Abstract] OR adenocarcin*[Title/Abstract] OR malig*[Title/Abstract]) OR ("Neoplasms"[Mesh] OR "Tumor"[Mesh] OR "Cancer"[Mesh])) AND (intestin*[Title/Abstract] OR digest*[Title/Abstract] OR gastr*[Title/Abstract] OR gut[Title/Abstract] OR epigastr*[Title/Abstract] OR stomach*[Title/Abstract]) OR ("Stomach Neoplasms"[Mesh] OR "Abdominal Neoplasms"[Mesh] OR "Stomach Cancer"[Mesh] OR "Abdominal Cancer"[Mesh] OR "Intestinal Neoplasms"[Mesh] OR "Stomach Carcinoma"[Mesh] OR "Stomach Carcinoid"[Mesh] OR "Stomach Carcinogenesis"[Mesh])) AND ("food intake"[Title/Abstract] OR drinking[Title/Abstract] OR eating[Title/Abstract] OR feeding[Title/Abstract] OR "feeding behavior"[Title/Abstract] OR (oral[Title/Abstract] AND intake*[Title/Abstract]) OR "feeding method"[Title/Abstract] OR food[Title/Abstract] OR fluid[Title/Abstract] OR water[Title/Abstract] OR solid[Title/Abstract] OR eat[Title/Abstract]) AND ("Gastrectomy"[Mesh]))	1281
Embase	((carcin*:ti, ab OR cancer*:ti, ab OR neoplas*:ti, ab OR tumour*:ti, ab OR tumor*:ti, ab OR cyst*:ti, ab OR growth*:ti, ab OR adenocarcin*:ti, ab OR malig*:ti, ab) OR ('neoplasm'/exp OR 'tumor'/exp OR 'cancer'/exp)) AND ((intestin*:ti, ab OR digest*:ti, ab OR gastr*:ti, ab OR gut: ti, ab OR epigastr*:ti, ab OR stomach*:ti, ab) OR ('stomach tumor'/exp OR 'abdominal tumor'/exp OR 'stomach cancer'/exp OR 'intestinal tumor'/exp OR 'stomach adenocarcinoma'/exp OR 'gastric carcinoid'/exp OR 'gastric carcinogenesis'/exp)) AND (('food intake':ti, ab OR drinking: ti, ab OR eating: ti, ab OR feeding: ti, ab OR 'feeding behavior':ti, ab OR (oral: ti, ab AND intake*:ti, ab) OR 'feeding method':ti, ab OR food: ti, ab OR fluid: ti, ab OR water: ti, ab OR solid: ti, ab OR eat: ti, ab)) AND ('gastrectomy'/exp)	1426
Scopus	(TITLE-ABS(carci*) OR TITLE-ABS(cancer*) OR TITLE-ABS(neoplas*) OR TITLE-ABS(tumour*) OR TITLE-ABS(tumor*) OR TITLE-ABS(cyst*) OR TITLE-ABS(growth*) OR TITLE-ABS(adenocarcin*) OR TITLE-ABS(malig*)) AND (TITLE-ABS(intestin*) OR TITLE-ABS(digest*) OR TITLE-ABS(gastr*) OR TITLE-ABS(gut) OR TITLE-ABS(epigastr*) OR TITLE-ABS(stomach*)) AND (TITLE-ABS("food intake") OR TITLE-ABS(drinking) OR TITLE-ABS(eating) OR TITLE-ABS(feeding) OR TITLE-ABS("feeding behavior") OR (TITLE-ABS(oral) AND TITLE-ABS(intake*)) OR TITLE-ABS("feeding method") OR TITLE-ABS(food) OR TITLE-ABS(fluid) OR TITLE-ABS(water) OR TITLE-ABS(solid) OR TITLE-ABS(eat)) AND TITLE-ABS(gastrectomy))	1,672
Web of Science	TS=(carcin* OR cancer* OR neoplas* OR tumour* OR tumor* OR cyst* OR growth* OR adenocarcin* OR malig*) AND TS=(intestin* OR digest* OR gastr* OR gut OR epigastr* OR stomach*) AND TS=("food intake" OR drinking OR eating OR feeding OR "feeding behavior" OR (oral AND intake*) OR "feeding method" OR food OR fluid OR water OR solid OR eat) AND TS=(gastrectomy))	1,436

gender), number of patients in each group, oral feeding schedule or protocol for each group, study design (e.g., randomized controlled trial or cohort study), surgical approach (e.g., laparoscopic or open), and use of multimodal care elements. EOF was operationally defined as initiation of oral intake within postoperative day (POD) 0–1, irrespective of diet composition or advancement schedule. Because included studies varied substantially in timing, volume, and type of intake, we considered all such regimens under the umbrella of EOF. The primary outcome was hospitalization time. Secondary outcomes included the incidence of postoperative complications, the number of participants in each group who tolerated early oral feeding, time to first anal exhaust, and levels of serum albumin and prealbumin. For methodological quality assessment, the following domains were extracted based on the risk of bias tools: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessors, completeness of outcome data, selective reporting, and other potential sources of bias. Any discrepancies between the two reviewers were first discussed to reach a consensus. If disagreement persisted, a third researcher (E.F.) was consulted to make the final decision.

Quality assessment

Two researchers (A.B and C.D) independently assessed the risk of bias of each included study based on Cochrane Collaboration's protocols [13]. The risk of bias for each study was assessed as low, unclear, or high, represented by green, yellow, and red colors, respectively. Additionally, the GRADE approach was utilized to evaluate the quality of each outcome [14]. Any disagreements were resolved through discussion among the reviewers, and if unresolved, a third researcher (E.F) was consulted to determine the final decision.

Statistical analysis

STATA version 18 software (StataCorp, College Station, TX) was used to analyze the data extracted from studies. Mean differences with 95% confidence intervals were determined for numerical variables, while risk ratios with 95% confidence intervals were calculated for categorical variables. Heterogeneity was evaluated by Cochran's Q-test and I^2 test. To investigate the factors contributing to any observed heterogeneity, a subgroup analysis was performed. The credibility of evidence was evaluated by GRADE profiler v.3.6 software (The Cochrane Collaboration, Oxford, UK) in accordance with GRADE recommendations. Both RCTs and cohort studies were eligible for inclusion. While RCTs provide higher internal validity, cohort studies were included to enhance comprehensiveness and precision. Given the similar populations and outcome definitions across study designs, we synthesized them together. Certainty of evidence was downgraded in the GRADE framework to reflect the lower level of evidence contributed by observational studies. The sample mean and standard deviation were estimated based on the methods outlined in the literatures and also using WebPlot Digitizer (Automeris LLC, Frisco, Texas) [15–17]. All statistical analyses were conducted using a two-tailed approach, with statistical significance being set at a p-value less than 0.05.

Publication bias assessment

Potential publication bias was evaluated for outcomes reported in at least ten studies using Egger's and Begg's tests. A p-value < 0.05 was considered statistically significant [18].

Results

Literature search

The initial search identified 5,815 studies. After removing duplicates, 2741 records were excluded based on title and abstract screening. Of the 180 full-text articles assessed, 15 studies met the eligibility criteria and were included in the meta-analysis. These comprised 12 randomized controlled trials [10, 19–29] and 3 cohort studies [18, 30–32], with a total of 1,847 participants (921 in EOF group and 926 in TOF group), (Fig. 1). The detailed characteristics of these studies are presented in Table 2.

Quality of the studies

Risk of bias was assessed using the ROBINS-I tool for the three non-randomized cohort studies and the Cochrane Risk of Bias tool for the thirteen randomized controlled trials (RCTs). Among the three cohort studies, all were judged to have moderate overall risk of bias, primarily due to concerns regarding confounding and deviations from intended interventions, as none of the studies employed randomization or adjusted for baseline differences. For the 12 RCTs, all studies demonstrated low risk of bias in random sequence generation, and most showed low risk for allocation concealment. However, all RCTs had high risk of bias due to lack of blinding of participants and personnel, which is expected given the nature of perioperative care interventions. The details of assessment of risk of bias of studies is shown in Figure S1and S2.

Result of meta-analysis

Hospital stay duration

Fourteen studies [10, 19–29, 31, 32] were included to assess the effect of EOF versus TOF on the length of hospital stay (Fig. 2). A random-effects model showed a statistically significant reduction in hospital stay in the EOF group compared to the TOF group (mean difference = −1.82 days; 95% CI: −2.30 to −1.34; $p = 0.00$). Considerable heterogeneity was observed among the studies (I^2 = 87.14%, $p = 0.00$). Subgroup analyses indicated that the reduction in hospital stay with EOF was consistent regardless of surgical approach (laparoscopic vs. open), extent of gastrectomy (partial vs. total), use of a multimodal postoperative protocol, or study design (Supplementary File, Figures S3 and S4) and, did not materially reduce heterogeneity, suggesting that variability in perioperative protocols and patient factors likely contributed.

Time to first anal exhaust

Fifteen studies [10, 19, 20, 22–32] reported the time to first anal exhaust following gastrectomy (Fig. 2). Using a random-effects model, pooled results showed that EOF significantly shortened this recovery milestone compared to TOF (mean difference = −0.85 days; 95% CI: −1.16 to −0.54; $p = 0.00$). Substantial heterogeneity was present (I^2 = 95.15%, $p = 0.00$). Subgroup analyses confirmed a consistently shorter time to first anal exhaust in the EOF group, regardless of surgical approach, gastrectomy extent, multimodal care, or study design (Supplementary File, Figures S5 and S6) and showed that heterogeneity persisted across all strata, indicating that differences in EOF initiation timing and diet progression schedules may account for residual variability.

Oral feeding tolerance

Eleven studies [19–25, 27, 28, 30, 31] evaluated oral feeding tolerance between the two groups (Fig. 3). A random-effects model yielded no statistically significant difference between EOF and TOF (Log OR = −0.20; 95% CI: −0.64 to 0.24; $p = 0.38$). No heterogeneity was detected. Subgroup analyses confirmed consistent findings and showed comparable results across all strata, including surgical approach, extent of gastrectomy, multimodal protocols, and study design (Supplementary File, Figures S7 and S8).

Postoperative complications

Postoperative complication rates were assessed in 15 studies [10, 19–32] (Fig. 3). A random-effects model indicated no significant difference in complication rates between EOF and TOF groups (Log OR = 0.00; 95% CI: −0.29 to 0.29; $p = 0.84$). No heterogeneity was detected. Subgroup analyses supported this finding across surgical methods, extent of surgery, postoperative protocols, and study types (Supplementary File, Figures S9 and S10).

Serum albumin levels

Five studies [23, 24, 27, 28, 31] compared serum albumin levels postoperatively between EOF and TOF groups. A random-effects model showed significantly

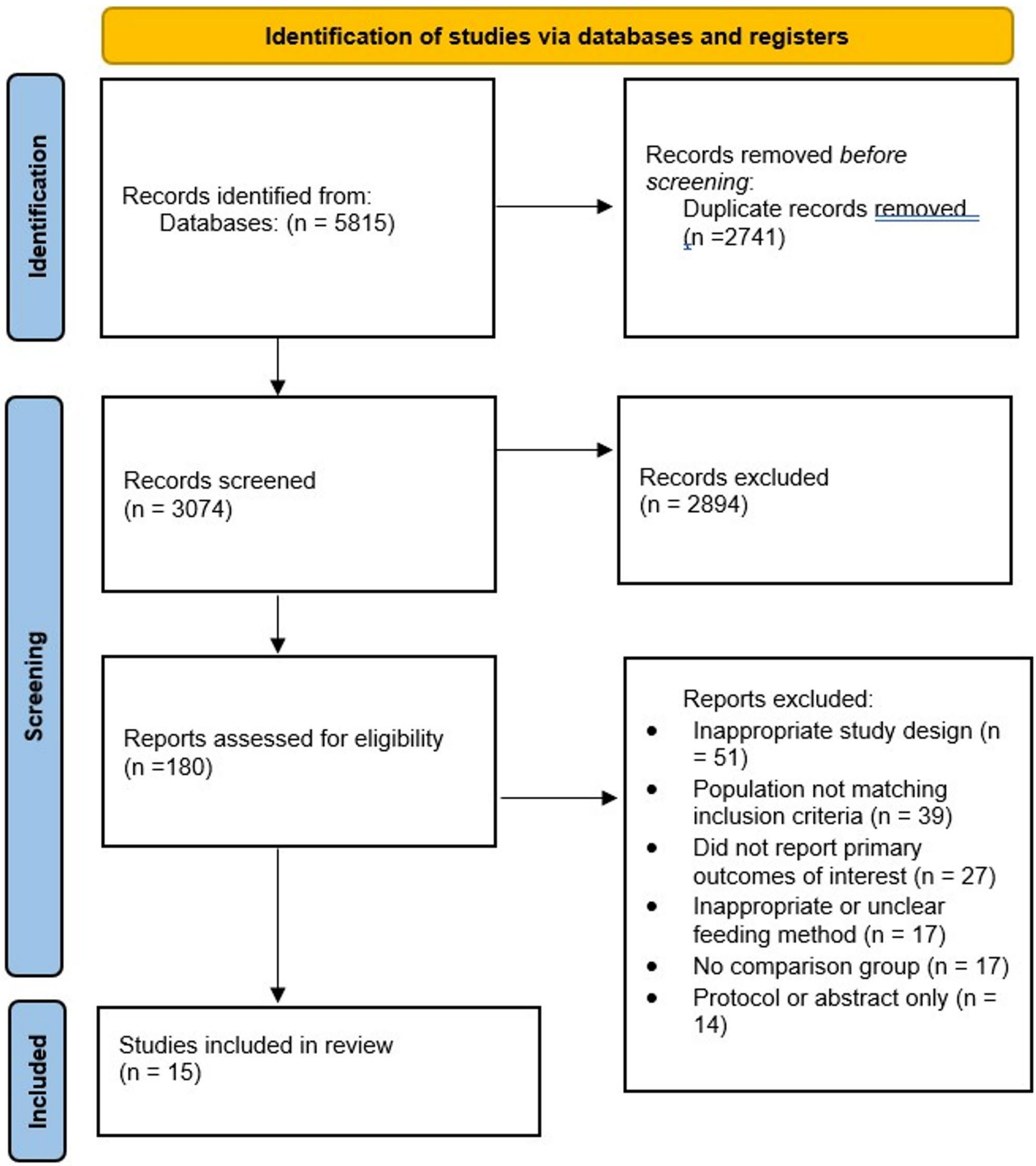

Fig. 1 Flowchart of study inclusion

higher albumin levels in the EOF group (mean difference = 2.96 g/L; 95% CI: 1.83 to 4.09; $p = 0.00$) (Fig. 4). Moderate heterogeneity was observed (I^2 = 59.43%, $p = 0.04$). Subgroup analyses showed heterogeneity persisted and revealed consistently higher albumin levels in EOF patients regardless of surgical technique, gastrectomy type, multimodal approach, or study design (Supplementary File, Figure S11). This analysis was informed by a limited number of studies (albumin: 5 studies, $n = 787$), contributing to imprecision in the GRADE assessment.

Table 2 Characteristics of included studies

Study	Country	Age	Gender (M/F)	Sample Size		Surgical Approach	Time of Oral Feeding		Study Type
				EOF	TOF		EOF	TOF	
Liu 2010 [20]	China	28–81	33/29	33	30	Open gastrectomy with lymph node dissection	POD 0: ~50 mL clear fluid POD 1: 50–100 mL semiliquid diet POD 2: 100–200 mL semiliquid diet POD 3: 200–400 mL semiliquid diet POD 4: Semiliquid diet POD 5: Solid diet	POD 1–3: Same stepwise reintroduction as EOF (post-bowel venting) POD 5: Semiliquid diet POD ≥ 5: Solid diet	RCT
Wang 2010 [19]	China	< 80	61/31	45	47	Open subtotal or total gastrectomy (standard D2)	POD 0: Small amount of clear water POD 1: 0.5 L liquid (stepwise to semi-fluids and normal diet) POD 2: 1 L liquid + progression POD 3: Continued progression	Initiated once bowel sounds return; followed same gradual progression to normal diet	RCT
Hur 2011 [21]	Korea	< 65 or ≥ 65	33/21	28	26	Open subtotal or total gastrectomy	POD 1: Sips of water POD 2: Liquid diet POD 3: Soft diet	POD 3: Sips of water POD 4–5: Liquid diet POD 6: Soft diet	RCT
Chen 2012 [23]	China	25–75	41/41	40	42	Laparoscopy-assisted or open distal gastrectomy	6–8 h post-op: Clear water → carb drink → semi-fluids → normal diet	Initiated after first flatus; gradual transition to normal diet	RCT
Kim 2012 [22]	Korea	Mean 55.05	-	22	22	Laparoscopic distal gastrectomy	POD 2: Clear liquids (dinner)POD 3: Clear liquid (breakfast), full liquid (lunch/dinner)POD 4: Soft diet (breakfast/lunch)	Initiated after flatus; one-step-per-day progression from clear → full liquid → soft diet	RCT
Mi 2012 [24]	China	58.6	33/27	30	30	Subtotal or total gastrectomy	POD 1: Small amount of water POD 2: 500 mL Jevity + water POD 3: 1,000 mL Jevity + liquid diet POD 4: 1,000 mL Jevity + increased liquid/semi-liquid diet	After first flatus, gradual progression: Water → liquid → semi-liquid diet	RCT
Feng 2013 [25]	China	28–75	85/34	59	60	Open D2 total gastrectomy	POD 0: 500–1,000 mL glucose saline POD 1: 2,000–3,000 mL liquid food (1,000–1,200 kcal/day)	Initiated after flatus; gradual advancement to semi-fluids and normal food	RCT
Hong 2014 [26]	China	18–75	59/25	40	44	Laparoscopic distal gastrectomy	POD 1–2: Clear liquid diet POD 3: Soft diet	POD 3–4: Clear liquid diet POD 5: Soft diet	RCT
Li 2015 [27]	China	Mean 59.8	154/146	150	150	Open radical gastrectomy	POD 1: Small sips of water POD 2: 500 mL oral enteral nutrition (fractionated)POD 3: 1,000 mL Jevity + liquid diet	Initiated after flatus; gradual progression from water to semi-liquid diet	RCT
Yu 2016 [28]	China	Mean 58.91	106/33	72	67	Laparoscopic distal gastrectomy	POD 1: Gradual progression: Water → liquid diet → semi-liquid diet	After flatus/defecation: Same stepwise oral intake as EOF	RCT
Shimizu 2018 [29]	Japan	20–80	137/79	102	114	Distal/total gastrectomy (lap or open)	POD 1–3: iEAT® diet POD 4: Regular hospital diet	Standard (non-early) nutritional management	RCT
Wang 2019 [10]	China	18–75	71/29	51	49	Total laparoscopic radical gastrectomy	POD 1: Liquid food (morning)POD 2–6: Liquid/semi-liquid based on tolerance	POD 4–6: Liquid food POD 7: Same diet as EOF group	RCT
Gao 2019 [30]	China	44–80	123/75	101	97	Laparoscopic gastrectomy	POD 2: Oral fluid diet POD 3: Semi-liquid/soft diet IV fluids used as needed	Initiated after flatus; gradual advancement to full diet	Prospective

Table 2 (continued)

Study	Country	Age	Gender (M/F)	Sample Size		Surgical Approach	Time of Oral Feeding		Study Type
Lu 2020 [31]	China	Mean 61.52	174/32	105	101	Laparoscopic total gastrectomy	POD 0: Warm water POD 1: Water, clear fluid, enteral nutrition Then: Liquid → semi-liquid → soft diet	Initiated after flatus/defecation Same stepwise advancement to soft diet; IV supplementation as needed	Prospective Cohort
Dai 2021 [32]	China	Mean 60.38	53/37	43	47	Laparoscopic radical gastrectomy	POD 0: Gum chewing + 200–300 mL water POD 1–3: Liquid diet (up to 2,200 mL) Post-flatus: Semi-liquid diet	NG tube removed POD 2–3 after gas passage Liquid within 5 days Normal diet resumed by POD 6	Cohort

Abbreviations: *EOF* Early Oral Feeding, *TOF* Traditional Oral Feeding, *RCT* Randomized Controlled Trial, *POD* Postoperative Day, *IV* Intravenous, *NG* Nasogastric

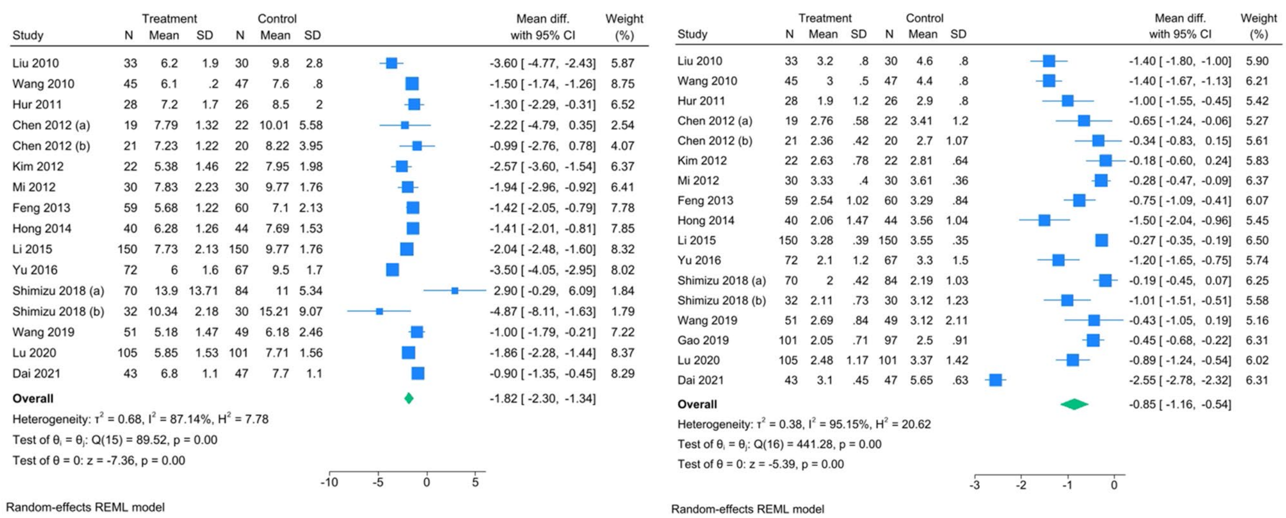

Fig. 2 Forest plots of hospital stay duration (left) and the time to first anal exhaust (right)

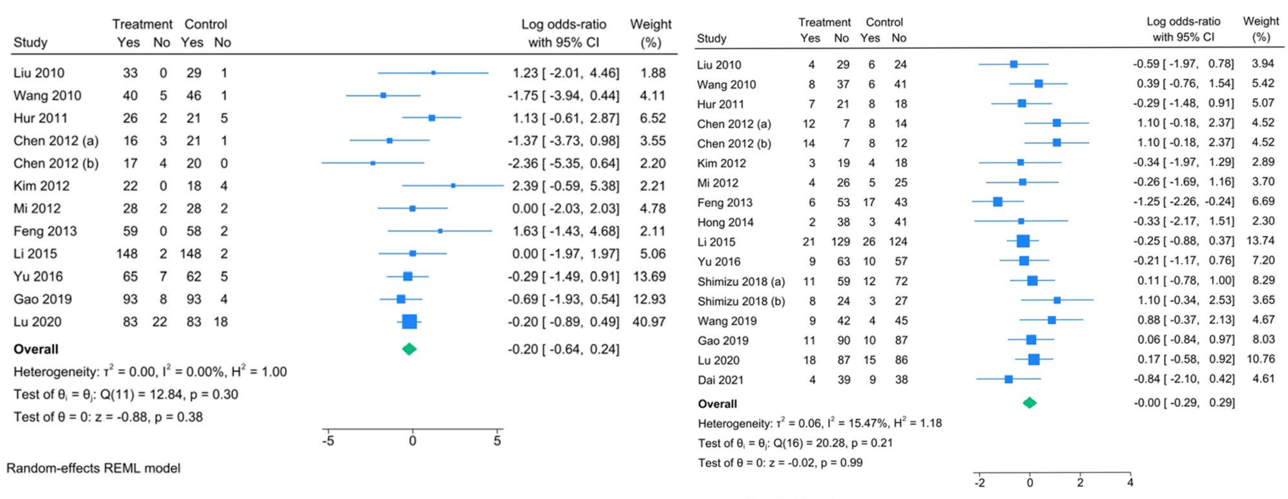

Fig. 3 Forest plots of oral feeding tolerance (left) and postoperative complications (right)

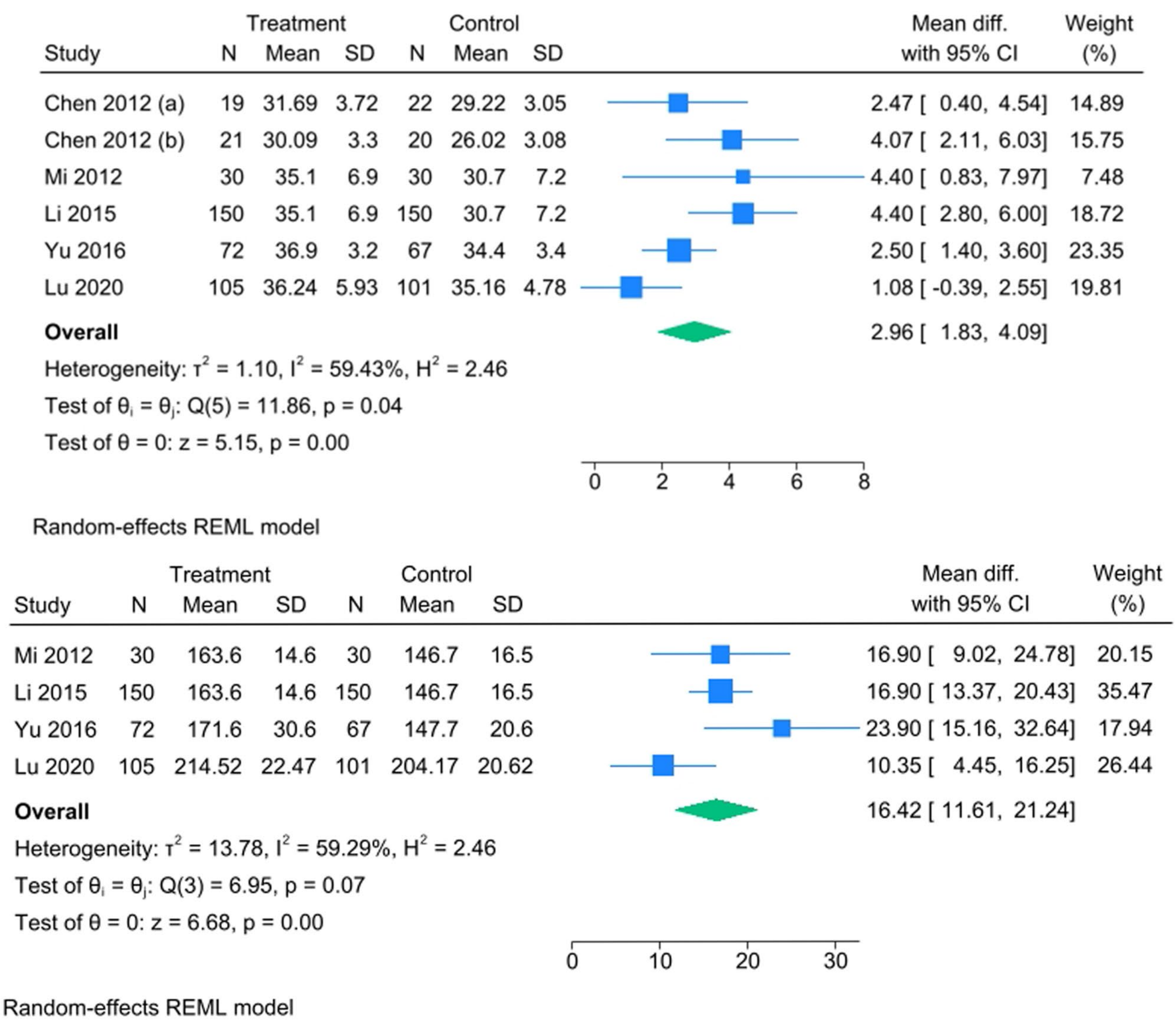

Fig. 4 Forest plots of serum albumin levels (above) and serum prealbumin levels (below)

Serum prealbumin levels

Four studies [24, 27, 28, 31] assessed postoperative prealbumin levels in EOF and TOF groups. Pooled analysis using a random-effects model showed significantly higher levels in the EOF group (mean difference = 16.42 mg/L; 95% CI: 11.61 to 21.24; $p = 0.00$) (Fig. 4). Moderate heterogeneity was present (I^2 = 59.29%, $p = 0.07$). Subgroup analyses did not substantially explain the observed variability and, indicated that EOF was associated with higher prealbumin levels across different surgical approaches and study designs (Supplementary File, Figure S12). This analysis was informed by a limited number of studies (4 studies, $n = 705$), contributing to imprecision in the GRADE assessment.

Publication bias

Funnel plots were generated for four outcomes to visually assess potential publication bias (Fig. 5), alongside Begg's and Egger's tests. Although some degree of asymmetry was observed in the funnel plots, both Begg's and Egger's tests were non-significant for all outcomes (e.g., LOS: Begg's $z = -1.04$, $p = 0.344$; Egger's $z = 0.20$, $p = 0.838$(, full statistics are reported in Table S2. These results suggest that publication bias is unlikely to have substantially influenced the findings of this meta-analysis.

Risk of bias within outcomes

The certainty of evidence for all outcomes was rated as very low based on the GRADE approach (Table S1). This was mainly due to serious risk of bias, as most studies were single-blinded and lacked proper reporting of allocation concealment. Inconsistency was found to be

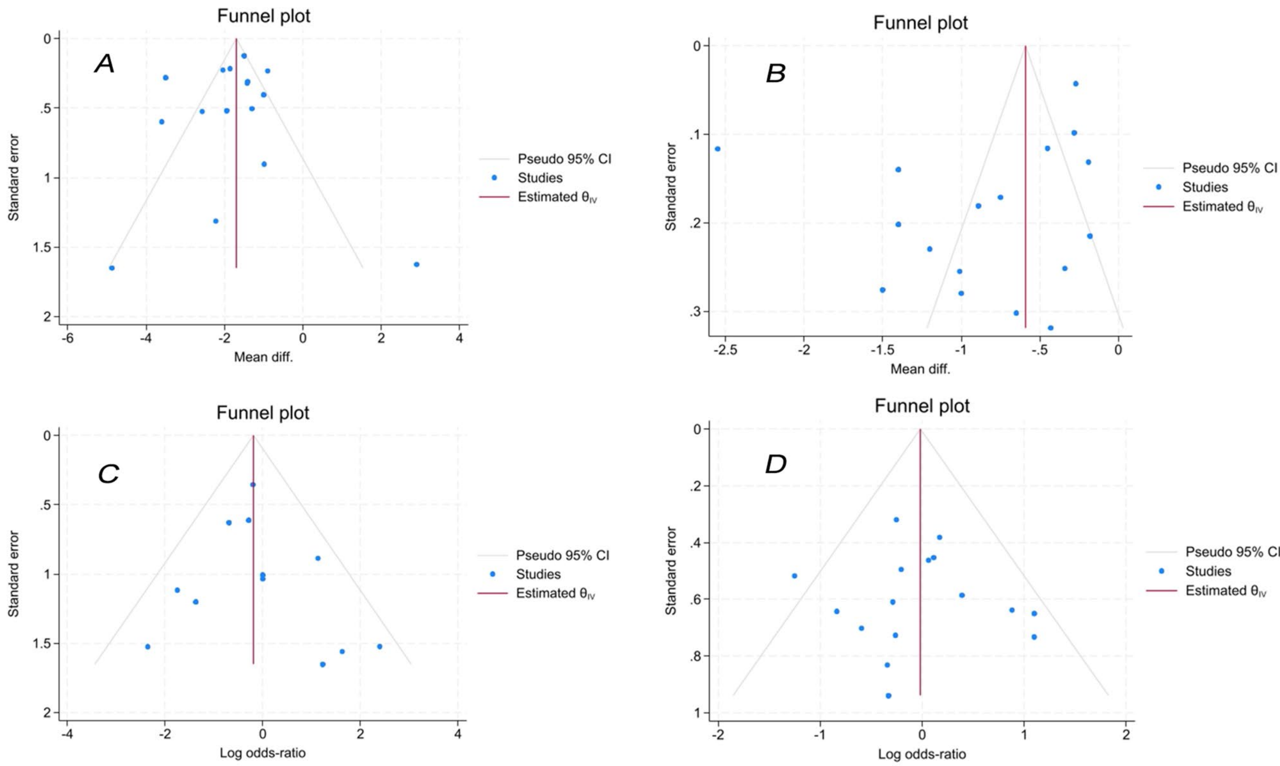

Fig. 5 Funnel plots for hospital stay duration (**A**), time to first anal exhaust (**B**), oral feeding tolerance (**C**), and postoperative complications (**D**)

serious for the anal exhaust time and hospital stay duration outcome due to high heterogeneity, while it was low for other outcomes. Imprecision was a concern for postoperative complications and feeding intolerance because their CIs included the possibility of no effect. It also affected albumin and prealbumin levels, as the sample sizes were small. Although funnel plots showed some asymmetry, especially for hospital stay, anal exhaust time, albumin, and prealbumin, both Egger's and Begg's tests were not significant. However, due to the small number of studies and visual concerns, publication bias could not be ruled out for these outcomes.

Consistency across study designs

Qualitatively, consistent directions of effect were observed in RCTs and cohort studies for all outcomes. While adding data from cohort studies increased precision, the strength of evidence was downgraded because of the higher risk of bias associated with non-randomized designs. As a result, the pooled effect estimates were driven mostly by evidence from RCTs, with the cohort study evidence being viewed as corroborating.

Discussion

This meta-analysis included 15 studies, 12 randomized controlled trials and 3 cohort studies, with a total of 1,847 patients. It compared postoperative outcomes in gastric cancer patients who received EOF versus TOF after gastrectomy. The findings indicated that EOF was associated with a significantly shorter hospital stay, earlier time to first anal exhaust, and improved postoperative nutritional status, as evidenced by higher levels of albumin and prealbumin. However, no significant differences were observed between the two groups in terms of postoperative complications or oral feeding tolerance.

Rehabilitation of patients undergoing surgery for gastric cancer remains one of the major challenges in gastrointestinal oncology. Among the key components of postoperative recovery is the restoration of gastrointestinal function, which is often impaired following surgery. Such dysfunction can lead to serious complications, including anastomotic leakage, malnutrition, and delayed wound healing [33]. To optimize postoperative recovery and minimize these risks, numerous interventions have been investigated. One such intervention is EOF, which is a fundamental element of Fast Track Surgery (FTS) and Enhanced Recovery After Surgery (ERAS) protocols. These multidisciplinary approaches aim to reduce surgical stress, maintain organ function, and accelerate postoperative recovery [34]. Alongside EOF, other core components of ERAS include optimized anesthesia and fluid management, adequate pain control, and early mobilization. While ERAS has shown clear benefits in surgeries such as colorectal and gynecological procedures, its role in gastric cancer surgery is still under active investigation [35].

Traditionally, surgeons have delayed the initiation of oral intake after gastric surgery due to concerns about potential complications such as anastomotic leakage and intestinal obstruction [36, 37]. However, recent studies challenge this conservative approach. Evidence increasingly suggests that waiting for the first passage of flatus before reintroducing oral nutrition does not improve outcomes [38, 39]. Notably, our results support this view, showing that EOF does not increase gastrointestinal intolerance, such as nausea, vomiting, or abdominal distension, nor does it elevate the risk of postoperative complications. This aligns with previous reports indicating that EOF is at least as safe as TOF [31, 40]. On the contrary, delayed feeding may prolong recovery of bowel function and increase the risk of pulmonary complications [41, 42]. Both animal and human studies have shown that EOF is either equivalent or superior to TOF in terms of complication rates and mortality, with the added benefit of earlier return of bowel activity and improved healing of intestinal tissues [43, 44].

Nonetheless, some conflicting findings exist. For example, Shimizu et al. [29] reported higher rates of delayed gastric emptying in the EOF group following distal gastrectomy, which may be due to the higher volume of food administered postoperatively in that group. Despite such variations, our meta-analysis supports the overall safety and efficacy of EOF compared to TOF, showing consistent results across different surgical approaches, extents of gastrectomy, and whether ERAS/FTS protocols were applied. These findings align with latest previous meta-analyses [45–48].

Our results also demonstrate that EOF significantly reduces hospital stay and shortens the time to first anal exhaust, consistent with earlier reviews [45–48]. One randomized controlled trial in oncologic patients undergoing intestinal resection reported faster return of bowel movements and better nutrient absorption in the EOF group. Further analysis in that study showed improved mucosal integrity and immune response, likely due to earlier gut stimulation [49]. Growing evidence also suggests that oral feeding positively influences gastrointestinal hormonal activity. Several studies have reported higher levels of gastrointestinal hormones on postoperative day 5 in EOF groups, potentially facilitating faster gastrointestinal recovery [30, 31, 50].

Nutritional biomarkers such as albumin and prealbumin are commonly used to assess postoperative nutritional and inflammatory status and are known to correlate with outcomes in gastric cancer patients [51, 52]. Our analysis found higher levels of both markers in the EOF group compared to TOF, suggesting better nutritional recovery. This is further supported by subgroup analysis. Delayed oral intake may promote villous atrophy and reduce gut absorptive capacity, whereas EOF seems to counteract these effects by supporting early nutritional replenishment [53]. However, one study by Wang et al. [10] found no significant difference in albumin and prealbumin levels between the two groups, possibly due to earlier measurement (within the first three postoperative days) compared to other studies that collected data at one-week post-surgery.

This meta-analysis has several limitations. First, although including both RCTs and cohort studies increased comprehensiveness, it also introduced variability in study quality; therefore, certainty of evidence was downgraded, and our conclusions were primarily informed by RCT findings. Second, heterogeneity remained substantial for some outcomes despite subgroup analyses, likely reflecting differences in surgical technique, extent of resection, ERAS implementation, and EOF protocols. Third, all included studies were conducted in East Asia, which limits generalizability to non-Asian populations with different patient characteristics, BMI, diet, and perioperative care. Fourth, patient-level data (e.g., cancer stage, baseline nutrition, comorbidities) were inconsistently reported, limiting further stratification. Fifth, most trials reported only short-term endpoints (LOS, early recovery, serum markers), whereas long-term outcomes such as nutrition, sarcopenia, quality of life, readmissions, and survival remain unknown. Sixth, albumin (5 studies; $n=787$) and prealbumin (4 studies; $n=705$) outcomes were based on small evidence bases, resulting in imprecision and very low certainty. Finally, EOF protocols varied (POD0 vs. POD1 initiation, diet type, volume, and advancement speed), which likely contributed to residual heterogeneity; standardized protocols and reporting are needed in future RCTs.

Conclusion

This meta-analysis supports the safety and potential benefits of EOF following gastrectomy in patients with gastric cancer. Compared to TOF, EOF was associated with shorter hospital stays, faster recovery of bowel function, and improved postoperative nutritional markers. Importantly, EOF did not increase the risk of complications or gastrointestinal intolerance, indicating that it is a safe alternative to delayed feeding. These findings suggest that EOF may be a valuable component of postoperative care and ERAS programs. Future high-quality randomized controlled trials are needed to standardize EOF protocols, evaluate long-term outcomes, and include more diverse patient populations to better inform clinical practice.

Supplementary Information

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Supplementary Material 1.

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Authors' contributions
L. M., R. D., N. R., and R. H. Z. contributed equally to this work and share first authorship. L. M., R. D., N. R., and R. H. Z. conceptualized and designed the study. Y. M., R. H. Z., and R. S. H. conducted the literature search and data extraction. M. J. and K. A. H. performed the statistical analysis. L. M. and R. D. supervised the study and were responsible for the overall content as the corresponding authors. N. D. provided critical revisions and contributed to the interpretation of the data. All authors read and approved the final manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
No new patient data were collected and ethical approval was not required.

Consent for publication
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Competing interests
The authors declare no competing interests.

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