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Review

Perioperative care in orthognathic surgery - A systematic review and meta-analysis for enhanced recovery after surgery

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ABSTRACT

The aim of this study was to determine whether implementing ERAS (Enhanced Recovery After Surgery) elements/protocols improves outcomes in orthognathic surgery (OGS) compared to conventional care. To achieve this, ERAS-specific perioperative elements were identified and literature on ERAS for OGS was systematically reviewed. Using PRISMA methodology and GRADE approach, 44 studies with 49 perioperative care elements (13 pre-, 15 intra-, 21 postoperative) were analyzed. While 39 studies focused on single elements, only five presented multimodal protocols, with three related to ERAS. Preoperative elements included antimicrobial and steroid prophylaxis and prevention of postoperative nausea and vomiting. Intraoperative aspects, especially anesthesiological, showed high evidence. Outcome parameters were heterogeneous: complications and postoperative pain were well-investigated with high evidence, while length of stay (LOS) and patient satisfaction received low to medium evidence. ICU LOS, healthcare costs, and readmission rates were underreported. The meta-analysis revealed significant results for pain reduction and trends towards fewer complications and shorter LOS in the ERAS group. Overall, ERAS protocols are not established in OMFS, particularly OGS. Further research is needed in pre- and postoperative care and standardized multimodal analgesia. The next step should be developing a comprehensive OGS protocol through a consensus conference and implementing it in clinical practice.

1. Introduction

The first "Enhanced Recovery after Surgery" (ERAS®) concepts, initially referred to as "fast-track" protocols and "enhanced recovery programme", were introduced by the Danish surgeon Dr. Henrik Kehlet in 1999 (Kehlet, 1997; Ljungqvist et al., 2017a). ERAS was initiated as a way to optimize perioperative patient care. It is an evidence-based, multimodal, and multidisciplinary perioperative care programme which focuses on reducing physiological stress and promoting recovery of function (Patel et al., 2014).

Following the publication of the first consensus paper on perioperative care for colon resection in 2001 (Fearon et al., 2005) the ERAS Society, an international non-profit professional society that promotes, develops, and implements, ERAS programmes, was founded in 2010 (Kehlet, 1997; Ljungqvist et al., 2017a). Since then, ERAS has become increasingly important in perioperative care and adapted for numerous other procedures in other surgical specialties (e.g. orthopaedics (Nelissen, 2020; Wainwright et al., 2020), hepatobiliary surgery (Noba et al., 2020), gastrointestinal surgery (Li et al., 2018a), gynecology (Meng et al., 2021), urology (Zhang et al., 2020), bariatric surgery (Zhou et al., 2021), vascular surgery (McGinigle et al., 2019), head and neck surgery (Dort et al., 2017)).

As early as 2001, members of the ERAS group were able to demonstrate different outcomes in similar surgical procedures and populations, suggesting the critical role of perioperative care to improving outcomes (Nygren et al., 2005). The implementation of ERAS-guidelines has fundamentally changed traditional patient care in surgical departments and standardized it on the basis of published evidence (Kehlet and Dahl, 2003; Ljungqvist, 2014; Ljungqvist et al., 2017b). The effectiveness of these guidelines has been extensively tested, confirmed, and demonstrates that ERAS can shorten recovery time, reduce postoperative complication rates while being cost-effective (Muller et al., 2009; Gustafsson et al., 2011; Group, 2015). In a meta-analysis of 38 randomized trials of enhanced recovery programmes in patients undergoing various

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surgical procedures (18 colorectal-, 6 upper gastrointestinal-, 5 genitourinary-, 5 joint-, 3 lung-, 1 aortic aneurysm repair surgery), Nicholson et al. showed a 20% shorter hospital length of stay (LOS) (approximately 1 day less) and a lower risk of all complications within 30 days (risk ratio 0.71, CI 0.60 to 0.86) (Nicholson et al., 2014).

Optimizing recovery is not achieved by isolated interventions; rather requires the integration of various care elements, emphasizing the crucial pursuit of synergy between each component. These interventions (or "elements") span pre-, intra-, and postoperative care and are integrated into an ERAS protocol. These include: preoperative education and counselling, perioperative antibiotics, corticosteroids and antiemetics, short-acting anxiolytics, goal-directed fluid management, multimodal opioid-sparing analgesia, early nutrition and mobilization (Dort et al., 2017; Ljungqvist et al., 2017a; McGinigle et al., 2019). Given that different facets of ERAS are executed by diverse medical and healthcare specialties operating in distinct departments, a multidisciplinary team approach is essential to successful ERAS implementation. Surgeons, anesthetists, nurses, dieticians, and physiotherapists collectively contribute their expertise to deliver comprehensive perioperative care.

The backbone of a successful ERAS process, and the actualization of its benefits post-implementation of the ERAS protocol, relies on continuous training for all members of the local ERAS team. Regular audits of compliance and the implementation of necessary changes to enhance practices are crucial. Achieving compliance of at least 70% for each of the elements of the ERAS protocol proves significant in improving outcomes (Gotlib Conn et al., 2015). Audits of process compliance and patient outcomes are therefore key factors for a successful ERAS programme.

Interestingly, despite these advances, research in the field of Oral and Maxillofacial Surgery (OMFS) and orthognathic surgery (OGS) is lacking. In 2017, Otero et al. criticized the reluctance in OMFS to challenge traditional beliefs despite evidence supporting fast-track surgery (Otero et al., 2017). For example, there is currently only one guideline for head and neck cancer surgery, published in 2017 by Dort et al., which consists of 17 ERAS elements (Dort et al., 2017). Currently, three independently developed ERAS protocols for OGS are known. These protocols are substantially different and do not fully incorporate the recommendations of the ERAS Society. Moreover, they do not entirely reflect the various elements of the ERAS protocol carried out by different professional groups and disciplines throughout the patient's hospital stay. The protocols focused on same-day discharge or on specific elements such as pain control and postoperative nausea and vomiting (PONV) (Ferrara et al., 2022; Hattori et al., 2023; Wahlstrom et al., 2023). A comprehensive evidence-based ERAS-typical protocol for OGS seems to be lacking.

The objective of this study was twofold. First, to systematically assess the quality of published ERAS protocols and elements of perioperative care for patients undergoing OGS. Second, to evaluate the impact of these elements on patient outcomes compared to conventional perioperative care strategies in a meta-analysis. The results of this assessment could then serve as the basis for an ERAS process for OGS, leading to a subsequent consensus conference and the formulation of a consensus statement for ERAS recommendations for OGS.

2. Material and methods

2.1. Study design

In a systematic review, clinical OGS studies that evaluated at least one aspect of perioperative care (pre-, intra-, or postoperative) following the ERAS principles and at least one "typical" outcome were included. In a first step, ERAS-specific pre-, intra- or postoperative elements were identified from different surgical disciplines. Based on this analysis, relevant search terms were defined for the OGS-specific literature analysis. The quality of the evidence was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. The results are grouped into ERAS-specific interventions and outcomes. A meta-analysis was then performed for the outcomes complications, LOS and postoperative pain. No assessment of compliance or measurement, audit, and feedback was conducted, as this work solely serves as the basis for developing a comprehensive ERAS protocol for OGS and preparing for a planned ERAS process.

2.2. Search strategy and criteria

The following focused question in the Patient, Intervention, Comparison and Outcome (PICO) style was posed (Stone, 2002): "Does the implementation of ERAS elements/protocols improve outcomes (e.g. LOS, ICU LOS, healthcare costs, complications, readmission rates, postoperative pain, patient satisfaction) in patients undergoing orthognathic surgery compared to conventional perioperative care strategies?". The aim of this review was to provide the best available evidence to assist clinicians in planning the treatment of patients undergoing OGS and to improve patient outcomes.

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations were followed for this systematic review (Page et al., 2021). The protocol was registered in PROSPERO, an international prospective registry for systematic reviews, with the registration number: CRD42023422900. PubMed, Cochrane Library, Web of science, Cinahl databases were initially searched to identify relevant publications on ERAS elements and/or protocols from January 2000 to May 2023. A further update was performed in December 2023. In addition, databases were manually searched to identify articles that may not have been detected in the initial search by reviewing references of included articles. Language was restricted to English. Studies had to evaluate at least one pre-, intra- or postoperative ERAS element and at least one of the following outcomes: LOS, ICU LOS, health care costs, complications, readmission rate, postoperative pain, and patient satisfaction. This approach potentially informs a subsequent ERAS process and is intended to provide a comprehensive overview of all outcome-improving elements of perioperative care. Surgery-specific outcomes, such as myofunctional and neurosensory rehabilitation, were also recorded. For each of these topics, a comprehensive search was carried out using the following terms: "ERAS", "enhanced recovery", "fast track", "early recovery", "multimodal care", "perioperative care" AND "orthognathic surgery". The specified key words, inclusion and exclusion criteria are displayed in Table 1.

2.3. Study selection and data extraction

Only studies involving patients over 15 years of age undergoing OGS (single jaw surgery, bimaxillary osteotomy, with or without adjunctive procedures such as genioplasty, removal of the 3rd molar) were included. In anticipation of a limited number of randomized controlled trials (RCTs) comparing ERAS with conventional perioperative treatment strategies (especially protocols), pro- and retrospective single-arm cohort and quasi-randomized studies case-control-studies with at least five patients in intervention group and case series (>5 patients) were included. Studies had to evaluate at least one pre-, peri- or postoperative intervention aimed at improving at least one of the outcomes of interest described above. Consequently, studies had to report on at least one of these outcomes to be included.

The titles and abstracts were screened separately by the two authors [AKB] and [BA] and duplicates were removed. The final selection of included studies was made after review by the two authors, who also reviewed the full texts and extracted the following information from all included publications: study design and year of publication, no. of patients, age and sex distribution of patients, type of osteotomies, ERAS elements applied pre-, peri- and postoperatively, and the outcomes of interest mentioned above (Supplementary Material Tables S1–4). Any disagreements or inconsistencies between authors regarding the

Table 1
Systematic search strategies.

Focused question (PICO)	Does the implementation of ERAS elements/protocols improve outcomes (e.g. LOS, ICU LOS, healthcare costs, complications, readmission rates, postoperative pain, patient satisfaction) in patients undergoing orthognathic surgery compared to conventional perioperative care strategies?	
Search strategy	Population	Patients over 15 years of age undergoing orthognathic surgery
	Intervention or exposure	Implementation of Enhanced recovery after surgery protocols and/or single elements
	Comparison	Conventional perioperative care strategies
	Main outcome(s)	LOS, ICU LOS, health care costs, complications, readmission rate, postoperative pain, patient satisfaction
	Additional outcome	Surgery specific outcomes such as myofunctional and neurosensory rehabilitation
	Search combination	"ERAS" *OR "enhanced recovery" *OR "fast track" *OR "early recovery" *OR "multimodal care" *OR "perioperative care" *OR AND "orthognathic surgery"
Database search	Electronic	PubMed, Cochrane library, Web of science, Cinahl
Selection criteria	Inclusion criteria	• Clinical studies at all levels of evidence, except expert opinion • Publications from January 2000 to October 2023 • Patients undergoing orthognathic surgery (single jaw surgery, bimaxillary osteotomy, with or without adjunctive procedures e.g. genioplasty, 3rd molar removal) • Published in English • Assess at least one endpoint • Assess at least one ERAS element (pre-, peri- or postoperative intervention)
	Exclusion criteria	• Case reports • Clinical studies with <5 treated patients • Reviews, meta-analyses • Patients receiving genioplasty only • Presence of other congenital anomalies • Patients younger than 15 years old

inclusion of a particular article and data extraction were discussed. Persistent disagreements were clarified by discussion with a third reviewer [RW]. The PRISMA flowchart shows the information flow through the various stages of review (Fig. 1).

2.4. Risk of bias/Assessment of quality of evidence

The risk of bias was assessed by both reviewers independently and according to the study design using the combination of Cochrane statements, the CONSORT statements, the MOOSE statement and the STROBE statements, as proposed by Ten-Heggeler et al. (Ten Heggeler et al., 2011). This combination resulted in the following six criteria: randomization, blinding of patients and/or examiners, definition of inclusion and exclusion criteria, selection of a representative population, use of identical treatment between groups except for the intervention, and detailed reporting of follow-up. Studies that met all the criteria were considered to have a low potential risk for bias. If one criterion was missing, a moderate risk of bias was assumed, and if two or more criteria were missing, studies were considered to have a high potential risk of bias (Table 3). The methodological quality of evidence for all included studies was assessed using the GRADE tool and was graded as high, moderate, low, or very low. The initial rating is based on the categorization of the evidence according to the study design. RCTs are considered high-quality evidence, while observational studies are considered low-quality evidence. After evaluating domains that could rate down (risk of bias, imprecision, inconsistency, indirectness, and publication bias) or rate up (large magnitude of effect, dose-response gradient, and confounding factors), the overall quality of evidence is adjusted accordingly (Guyatt et al., 2008). Refer to Supplementary Material Table S4 for evidence levels of all studies, accompanied by the rationale for any downgrades or upgrades.

2.5. Statistical analysis

Meta-analysis was performed using RevMan Web [Version: 7.12.0, The Cochrane Collaboration 2024; RevManWeb, 2024)]. The Mantel-Haenszel method was employed to statistically compare dichotomous data, while inverse variance methods were applied for continuous variables. A 95% confidence interval (CI) was reported for both odds ratio (OR) and mean difference (MD). The I^2 value was used to quantify statistical inconsistency, defined as the percentage of variation between included studies due to heterogeneity (Higgins et al., 2003). To account for clinical heterogeneity, a random effects model was employed for the meta-analyses. An I^2 value exceeding 50% was considered significant heterogeneity. If a study provided medians and ranges instead of means and standard deviations, the latter were calculated in accordance with the methodology proposed by Hozo et al. (2005). Forest plots were created using the random effects model, which accounts for variation in effect size between studies. A p-value less than 0.05 was considered statistically significant.

3. Results

3.1. Study selection

The initial search strategy identified a total of 400 potential studies (PubMed/MEDLINE = 284, Cochrane Library = 25, Web of Science = 82, Cinahl = 6, and additionally, 3 records identified through other sources). The PRISMA flowchart is shown in Fig. 1. After removal of duplicates, 340 studies remained for whose titles and abstracts were read. Of these, 106 were selected according to the predefined eligibility criteria (Table 1). After full-text assessment, 44 studies were finally included in the qualitative analysis (reasons for exclusion from the full-text search are shown in Figs. 1) and 24 studies in the quantitative analysis (Table 5). The majority of the 24 studies compared elements that could potentially be incorporated into a future ERAS protocol with controls or alternative interventions. Only two studies, using a retrospective study design, compared ERAS with non-ERAS protocols.

3.2. Study characteristics

Of the 44 studies included in the qualitative synthesis, 39 investigated single elements of perioperative care (13 studies pre-, 11 studies intra- and 15 studies postoperative "ERAS" elements). Five studies reported on protocols incorporating multiple elements, with three explicitly labeling them as ERAS. However, only two of these embraced multimodal, multidisciplinary perioperative management, both surgical and anesthetic, aiming to reduce hospital LOS (Ferrara et al., 2022; Hattori et al., 2023). The third so-called "ERAS" protocol focused solely on a multimodal anesthesiological approach to reduce pain and PONV (Wahlstrom et al., 2023). Another study outlined a multimodal antiemetic (non-ERAS mentioned) protocol and its impact on nausea and vomiting after discharge (PDNV) (Brookes et al., 2015).The remaining study was entirely an interdisciplinary myofunctional rehabilitation protocol (called Early-RAS protocol) (Oliveira et al., 2021). Because no protocol (whether labelled as ERAS or not) comprehensively meets the requirements of an ERAS protocol, the general term "protocol" will be used in the following text to avoid misunderstandings.

Regarding the outcome parameters analyzed, the study results are very heterogeneous. The percentage distribution of analyzed outcomes across all studies is shown in Table 2. In terms of research content,

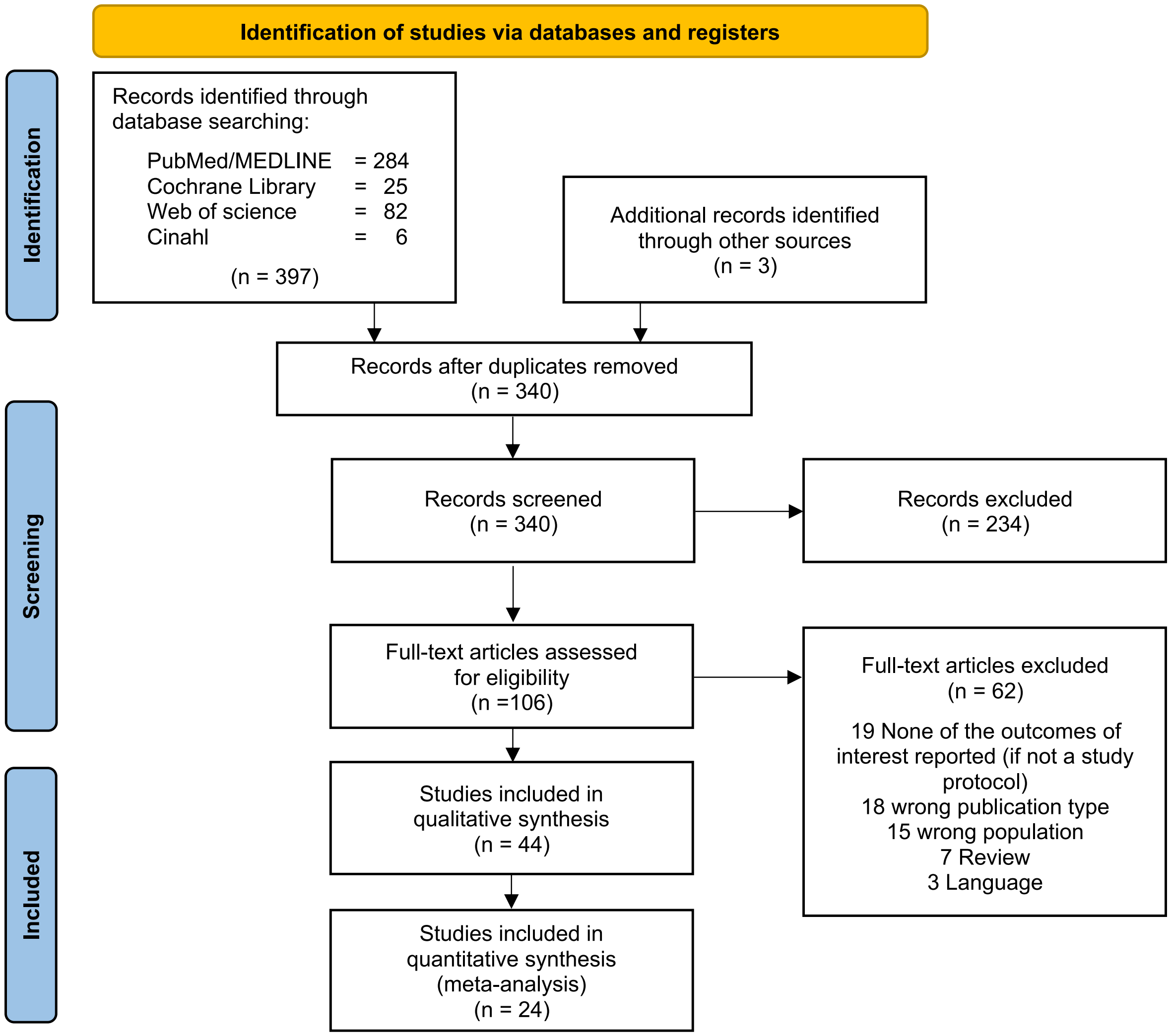


Fig. 1. PRISMA flowchart detailing selection of studies.

Table 2
Percentage distribution of the analyzed main outcomes across all studies.

Main Outcome	No. of studies % (n)
LOS	**13** (11)
ICU LOS	**4** (3)
Costs	**4** (3)
Complications	**38** (31)
Readmission Rate	**2** (2)
Postop Pain	**26** (21)
Pt Satisfaction	**13** (11)

complications (38%, 31 studies) and postoperative pain (26%, 21 studies) were the most commonly investigated outcomes, followed by patient satisfaction (13%, 11 studies) and LOS (13%, 11 studies). The least attention was paid to ICU LOS and healthcare costs (4% each, 3 studies) and readmission rates (2%, 2 studies).

The identified ERAS elements are listed in Supplementary Material Table S1 and the identified protocols are summarized in Supplementary Material Table S2. Details of the study characteristics, including study design, type of intervention, treatment groups and demographics, are presented in Supplementary Material Table S3.

Out of the 24 studies included in the quantitative synthesis, 17 were RCTs and seven were observational studies, with three of them being prospective. In total, 22 studies focused on single elements of perioperative care (7 pre-, 10 intra-, and 5 postoperative “ERAS” elements). Two studies, which used a retrospective design, compared ERAS with non-ERAS protocols. A meta-analysis was conducted for complications (23 studies), LOS (5 studies), and postoperative pain (6 studies). Table 5 provides a summary of the studies included in the meta-analysis.

3.3. Risk of bias and level of evidence

The quality assessment showed a high degree of variability among the included studies. The risk of bias for each study is detailed in Table 3. Fig. 2 shows the risk of bias divided into pre-, intra-, postoperative ERAS element and protocols. 50% (n = 22) of the studies had a high potential risk of bias, 4 studies (9%) had a moderate risk of bias and 18 studies (41%) had a low risk of bias.

The quality of the evidence across all studies shows that more than a third (39%, 17 studies) had moderate evidence. Just under a third achieved a high level of evidence (27%, 12 studies) and 34% showed a low (23%, 10 studies) to very low (11%, 5 studies) level of evidence (Fig. 3). The evidence level for each study is detailed in Supplementary Material Table S4, accompanied by the rationale for any downgrades or upgrades.

Especially in the field of pre- and intraoperative anesthesiological interventions a low risk of bias and a high level of evidence were found. Preoperatively, antimicrobial and steroidal prophylaxis and PONV prophylaxis are well studied, as are intraoperative anesthetics,

Table 3
Quality criteria of the included articles.

Authors & Year	Randomization	Blinding	Appropriate and clearlyfocusedquestion of the study	Defined criteria for 1. Inclusion2. Exclusion	No. of Pts	Follow-ups completed/ dropouts/ reasonfor dropout (yes/ no)	Conflict of interest	Source of funding	Risk of bias
Jansisyanont et al. (2008)	Yes	Yes	Yes	1. Yes 2. Yes	122	Yes	No	Faculty of Dentistry, Chulalolongkorn University	Low
Mahendran et al. (2022)	No	No	Yes	1. No 2. No	45	Yes	No	ND	High
Li et al. (2018b)	No	No	Yes	1. Yes 2. No	26	Yes	ND	Stanford Med Scholarship Grant	High
Lee et al. (2020)	Yes	Yes	Yes	1. Yes 2. Yes	57	Yes	No	National Research Foundation of Korea grant from the Korean government (MSIP) (NRF-2017R1A2B4009478)	Low
Kim et al. (2015)	Yes	Yes	Yes	1. Yes 2. Yes	72	Yes	No	National Research Foundation (NRF) funded by the Ministry of Science, ICT & Future Planning (No. 2014004407)	Low
Ko et al. (2015)	No	No	Yes	1. Yes 2. Yes	63	ND	No	Research grant (CMRPG 381623) from Chang Gung Memorial Hospital	High
Teng et al. (2015)	No	No	Yes	1. Yes 2. Yes	63	Yes	No	Research grant (CMRPG 381623) from Chang Gung Memorial Hospital	High
(Lee and Curtin, 2020)	Yes	Yes	Yes	1. Yes 2. Yes	30	Yes	No	Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, University of Hong Kong	Low
Ferrara et al. (2022)	No	No	Yes	1. Yes 2. Yes	359	Yes	No	Grant from the Regional Research Committee of Kaiser Permanente Southern California, RRC grant number: KP-RRC-2019006.	High
Bertuit et al. (2021)	Yes	Yes	Yes	1. Yes 2. Yes	107	Yes	No	No	Low
Ishikawa et al. (2019)	No	No	Yes	1. No 2. No	89	No	No	No	High
Bergonzani et al. (2022)	Yes	No	Yes	1. Yes 2. Yes	48	Yes	No	ND	Moderate
Abukawa et al. (2017)	Yes	Yes	Yes	1. Yes 2. Yes	24	Yes	No	Tokyo Medical University Research Grants	Low
Eftekharian et al. (2015)	Yes	Yes	Yes	1. Yes 2. Yes	56	Yes	ND	ND	Low
Caverni et al. (2005)	Yes	Yes	Yes	1. Yes 2. Yes	120	Yes	ND	ND	Low
Chegini et al. (2012)	No	No	Yes	1. Yes 2. Yes	51	No	No	ND	High
(Wong and Leung, 2023)	Yes	Yes	Yes	1. Yes 2. Yes	98	Yes	No	ND	Low
Semper-Hogg et al. (2017)	Yes	No	Yes	1. Yes 2. Yes	38	Yes	No	Article processing charge: German Research Foundation (DFG) & Albert Ludwigs University Freiburg	Moderate
(Rummasak and Apipan, 2014)	Yes	(Yes)	Yes	1. Yes 2. Yes	40	Yes	ND	ND	Low
Riekert et al. (2019)	No	No	Yes	1. Yes 2. Yes	117	Yes	No	No	High
Rummasak et al. (2011)	No	No	Yes	1. Yes 2. Yes	208	No	ND	ND	High
(Sousa and Turrini, 2019)	No	No	Yes	1. No 2. No	30	No	ND	ND	High
Tuzuner et al. (2007)	Yes	No	Yes	1. Yes 2. Yes	36	Yes	ND	ND	Moderate
Vural et al. (2019)	Yes	Yes	Yes	1. Yes 2. Yes	101	Yes	No	ND	Low

(continued on next page)

Table 3 (*continued*)

Authors & Year	Randomization	Blinding	Appropriate and clearlyfocusedquestion of the study	Defined criteria for 1. Inclusion2. Exclusion	No. of Pts	Follow-ups completed/ dropouts/ reasonfor dropout (yes/ no)	Conflict of interest	Source of funding	Risk of bias
Hattori et al. (2023)	No	No	Yes	1. No 2. No	143	Yes	No	No	High
Tabrizi et al. (2012)	No	No	Yes	1. Yes 2. No	62	No	ND	ND	High
Tan et al. (2011)	Yes	Yes	Yes	1. Yes 2. Yes	42	Yes	No	No	Low
Oliveira et al. (2021)	Yes	Yes	Yes	1. Yes 2. Yes	19	Yes	ND	ND	Low
Nagatsuka et al. (2000)	Yes	Yes	Yes	1. Yes 2. No	82	Yes	ND	ND	Low
(Miloro and Repasky, 2000)	No	No	Yes	1. Yes 2. Yes	6	Yes	ND	ND	High
Wahlstrom et al. (2023)	No	No	Yes	1. Yes 2. Yes	56	Yes	No	No	High
Phillips et al. (2001)	Yes	No	Yes	1. Yes 2. Yes	146	Yes	No	NIH grants DE10028 and DE05215	Moderate
Park et al. (2015)	No	No	Yes	1. No 2. No	250	NA	ND	ND	High
Watanabe et al. (2022)	No	No	Yes	1. Yes 2. Yes	9	Yes	No	No	High
Brookes et al. (2015)	No	No	Yes	1. Yes 2. Yes	182	Yes	ND	National Institutes of Health grant R01 DE 005215	High
Cacho et al. (2022)	Yes	(Yes)	Yes	1. Yes 2. Yes	47	Yes	No	No	Low
Goswami et al. (2021)	Yes	Yes	Yes	1. Yes 2. Yes	30	Yes	No	No	Low
Baqain et al. (2004)	Yes	Yes	Yes	1. Yes 2. Yes	34	Yes	ND	ND	Low
Naros et al. (2023)	No	No	Yes	1. Yes 2. Yes	291	NA	No	No	High
Eshghpour et al. (2014)	Yes	Yes	Yes	1. Yes 2. Yes	50	Yes	ND	ND	Low
Prevost et al. (2023)	No	No	Yes	1. Yes 2. Yes	102	Yes	No	No	High
Kim et al. (2009)	No	No	Yes	1. Yes 2. No	44	No	ND	ND	High
Fenner et al. (2009)	No	No	Yes	1. Yes 2. Yes	105	Yes	ND	ND	High
Beccuti et al. (2022)	No	No	Yes	1. Yes 2. Yes	46	Yes	No	No	High

analgesics, antihypertensives and local anesthetics. Studies on postoperative ERAS elements and protocols mostly showed moderate and low evidence.

3.4. ERAS elements

A total of 49 ERAS elements (13 pre-, 15 intra- and 21 postoperative) were identified, whereby the quality assessment revealed a high risk of bias for the included literature. Table 4 lists all identified elements according to pre-, intra- and postoperative phases. The postoperative period can be further subdivided into discharge and follow-up. A total of 31 ERAS elements were addressed in the five studies of the protocols. The detailed ERAS elements and protocols, with the corresponding references and intervention effects, are presented in Supplementary Material Tables S1–2.

Elements that were only used as part of the multimodal protocols in the intervention groups, and therefore have no specifically assessed outcome, include preoperative multidisciplinary team discussion and nutrition counselling (Wahlstrom et al., 2023). In the study by Wahlstrom et al., the latter was initially provided as free counselling by the nutrition department. Due to low attendance and non-positive feedback from those who did attend, nutritional counselling was reintroduced as part of the preoperative consultation by the surgeon. Other elements include oral carbohydrate loading (Wahlstrom et al., 2023), pre-anesthetic anxiolytics (Brookes et al., 2015), virtual surgical planning using 3D systems and CT scanning (in an anesthetic protocol to reduce intubation trauma) (Ferrara et al., 2022).

The use and outcome of PONV prophylaxis is very well studied in all included protocols (Caverni et al., 2005; Brookes et al., 2015; Ferrara et al., 2022; Hattori et al., 2023; Wahlstrom et al., 2023). Intraoperatively, this list includes perioperative fluid management. The implementation varies from goal directed, generalized fluid restriction (max. 1 l) to crystalloid flow rates of at least 5–10 ml/kg/h (Caverni et al., 2005; Brookes et al., 2015; Ferrara et al., 2022). There is consensus on the use of deliberately hypotensive anesthesia with a mean arterial pressure (MAP) range of 50–70 mmHg (Caverni et al., 2005; Kim et al., 2015; Ferrara et al., 2022; Hattori et al., 2023). This list also includes avoidance of long-acting opioids (Brookes et al., 2015; Ferrara et al., 2022; Hattori et al., 2023), intermaxillary fixation with minimal to light rubber bands over orthodontic brackets (Oliveira et al., 2021; Ferrara et al., 2022), wound drainage management (suction drainage if indicated, avoidance of capillary drainage) (Hattori et al., 2023; Naros et al., 2023) and avoidance of nasogastric tubes (Brookes et al., 2015).

Postoperative elements include observation in the PACU and on the ward rather than routine admission to the ICU (Brookes et al., 2015; Ferrara et al., 2022), early mobilizations and early intake of fluids and

Table 4
ERAS elements identified in the studies and no. of studies for each element (italics: elements used only in complete protocols).

Preoperativ		*Intraoperativ*		*Postoperativ*	
ERAS Elements	**No. of studies**	**ERAS Elements**	**No. of studies**	**ERAS Elements**	**No. of studies**
Multidisciplinary team discussion	1	Surgical approaches for Quality of Life	1	Extubation time	1
Pt education	4	Local anesthesia	6	Swelling and pain prevention - local application (Hilotherm)	1
Nutritional assessment	1	Antifibrinolytic	3	Pain prevention - Supplements (Melatonin prophylaxe)	1
Oral carbohydrate loading	1	*Perioperative fluid management*	3	Pain prevention - *Postop analgesia*	3
Antibiotic Prophylaxis	7	Intraop Blood management	1	Pain prevention - Preop analgesia	1
Steroid prophylaxis	5	*Anesthetic agents used -Induction*	3	Pain prevention - Effect of circadian changes in the pain threshold	1
Blood management	2	Anesthetic agents used -Maintenance	7	Improvement of nasal respiratory symptoms	1
Preanesthetic medications - Hypotension Drug	1	Anesthetic agents used- Hypotensive drug	3	Early rehabilitative physiotherapy	3
Preanesthetic medications -multimodal analgesic regimen	3	*Hypotensive Anesthesia*	4	Recovery oral function	2
Preanesthetic medications - Anxiolysis	1	Intraop (multimodal) analgesia	5	Neurosensory recovery	2
PONV prophylaxis	5	*Avoidance of Long-acting opioids*	3	*PACU observation*	2
CT-Scan	1	Pharyngeal Packing (soaked)	1	*Early intake of fluids & solids*	1
Surgical planning	1	*Intermaxillary fixation*	2	*Early mobilization*	1
		Wound drainage system	1	Nutritional assessment	1
		Avoidance nasogastric tube	1	*Rescue analgesia*	3
				Antiemetics	4
				Discharge & FU	
				Discharge criteria standardization	2
				Early discharge	2
				Predictive factors for Outpatient OGS	1
				Postop instructions on possible complications & return to hospital	1
				Satisfaction evaluation	2

solids (Ferrara et al., 2022), a fixed regimen for PONV management and rescue analgesia (Brookes et al., 2015; Ferrara et al., 2022; Hattori et al., 2023; Wahlstrom et al., 2023). Interventions related to discharge and follow-up are also largely part of the multimodal protocols. These include standardization of discharge criteria (PADSS score >13, no evidence of active/excessive bleeding, intact airway reflexes, ability to swallow liquids without difficulty, age-appropriate behaviour and voiding adequate volumes without difficulty), early discharge (<24 h), instructions on potential complications and return to hospital (Ferrara et al., 2022; Hattori et al., 2023).

Elements that have been evaluated individually in the studies, not as part of a multimodal interdisciplinary protocol, include preoperative counselling and education of patients to adjust their expectations of the postoperative period, e.g. through computerized treatment simulation, psychoeducationally based group interventions, or an educational mobile application (OrtogApp). Preoperative antimicrobial and steroid prophylaxis have been well studied. In addition to the various antibiotics (mainly from the penicillin and cephalosporin group), the RCTs also compared the dosage, method of administration and duration. Only in the multimodal antiemetic protocol by Brookes et al. is a macrolide antibiotic (erythromycin) given in the intervention group. With the exception of Brookes et al. (methylprednisolone), four studies used dexamethasone in varying doses for steroid prophylaxis. The studies on perioperative blood management showed a generally low transfusion rate, suggesting that type and screening tests and ABO/Rh status are appropriate precautions in OGS. The local anesthetics used intraoperatively are ropivacaine, lidocaine, bupivacaine, mepivacaine and xylocaine. As an antifibrinolytic agent, tranexamic acid is administered locally as an irrigation solution or intravenously. Anesthetic interventions have been studied with a relatively high level of evidence, such as hypotensive drugs (preoperative enalapril or atenolol, intraoperative dexmedetomidine, nitroglycerin or clonidine) and the anesthetic agents used for maintenance, as well preoperative and intraoperative analgesia. The number of studies on early functional rehabilitation (neurosensory, myofunctional) is comparable to that on postoperative pain prevention, although with a lower level of evidence.

3.5. Main outcomes

Evidence in terms of outcomes for specific ERAS elements and protocols, with references, are presented in Supplementary Material Table S4. Fig. 4 provides an overview of the number of studies found for each outcome, divided into pre-, intra- and postoperative ERAS elements and protocols.

3.6. LOS

LOS was reported in 11 studies, including 3 studies with protocols. Overall, LOS was shorter in the studies with protocols (86.8–99.3% same day discharge with a maximum of one overnight stay vs. mean range 3–8 days). In the study by Ferrara et al. the LOS was significantly shorter in the ERAS group than in the control group (15.5 h vs. 34.1 h; $p < 0.01$) (Ferrara et al., 2022). In the study by Prevost et al. 58.8% of patients were scheduled as outpatients, 65% of whom were discharged the same day. Factors such as age over 22 years, absence of associated procedures, end of procedure before 1 p.m., absence of postoperative vomiting and avoidance of morphine administration were significantly associated with the success of outpatient treatment. The average LOS for inpatients in the study was 1.7 days. Prolonged LOS was significantly associated with the type of surgery (bimaxillary osteotomy 71.2%) and scheduled

Table 5

Summary of included studies in Meta-Analysis for Complications, Length of Stay (LOS), and Pain (The studies included in each meta-analysis are highlighted in bold. If "Yes" is not in bold, there was insufficient information available for the analysis.).

	Elements	Study	Design	Intervention	Comparison	Complications	LOS	Pain
Preoperative	Antibiotic Prophylaxis	Jansisyanont et al. (2008)	RCT	short vs.	long	**Yes**	No	No
		Tan et al. (2011)	RCT	oral vs.	IV	**Yes**	No	Yes
		Baqain et al. (2004)	RCT	short vs.	long	**Yes**	No	Yes
		Eshghpour et al. (2014)	RCT	short vs.	long	**Yes**	No	No
	Steroid prophylaxis	Abukawa et al. (2017)	RCT	Dexamethasone	Control	**Yes**	No	No
		Semper-Hogg et al. (2017)	RCT	Dexamethasone	Control	**Yes**	No	No
	Preanesthetic medications	Kim et al. (2015)	RCT	Antihypertensiva	Control	**Yes**	**Yes**	No
Intraoperative	Local anesthesia	Bertuit et al. (2021)	RCT	Ropivacaine	Control	**Yes**	No	Yes
	Antifibrinolytic	Eftekharian et al. (2015)	RCT	Tranexamic acid solution	Control	**Yes**	No	No
	Blood management	Lee et al. (2020)	RCT	Iron	Control	**Yes**	Yes	No
	Anesthetic protocol	Caverni et al. (2005)	RCT	TIVA	balanced anesthesia	**Yes**	No	Yes
		Chegini et al. (2012)	RS	TIVA	balanced anesthesia	**Yes**	No	Yes
		Tabrizi et al. (2012)	PS CCS	TIVA	balanced anesthesia	**Yes**	No	Yes
	Hypotensive drug	Rummasak& Apipan (2014)	RCT	Dexmedetomidine	Nitroglycerin	**Yes**	No	**Yes**
		Goswami et al. (2021)	RCT	Dexmedetomidine	Clonidine	**Yes**	No	
	Intraop multimodal analgesia	Nagatsuka et al. (2000)	RCT	Diclofenac rectal + butorphanol IV + lidocaine local	Control	No	No	**Yes**
	Pharyngeal Packing (soaked)	Vural et al. (2019)	RCT	Chlorhexidine gluconate + benzydamine hydrochloride	Control	**Yes**	No	**Yes**
Postoperative	Extubation time	Riekert et al. (2019)	RS	Early extubation	Late extubation	**Yes**	**Yes**	No
	Pain prevention& Neurosensory recovery	Lee and Curtin (2020)	RCT	Melatonin	Control	**Yes**	**Yes**	**Yes**
	Pain prevention preop analgesia	Tuzuner et al. (2007)	RCT	Tramadol/diclofenac	Control	**Yes**	No	**Yes**
	Early rehabilitative physiotherapy-sEMG-activity	Ko et al. (2015)	PS CCS	Early rehabilitation	Control	**Yes**	No	Yes
	Early rehabilitative physiotherapy-mandibular motion	Teng et al. (2015)	PS CCS	Early rehabilitation	Control	**Yes**	No	Yes
Protocol	Same-Day Discharge & Reduction of Opioid Use	Ferrara et al. (2022)	RS	ERAS-protocol	Control	**Yes**	**Yes**	Yes
	PONV&Pain-prevention	Wahlstrom et al. (2023)	RS	ERAS-protocol	Control	**Yes**	**Yes**	**Yes**

CCS = Comparative Cohort Study; PS = prospective study; RCT = randomized controlled trial; RS = retrospective study.

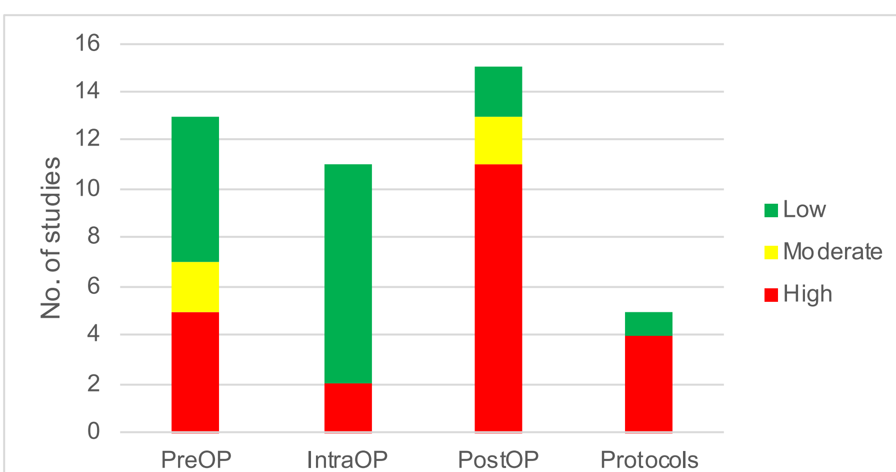


Fig. 2. Overview Risk of bias divided into pre-, intra-, postoperative ERAS elements and protocols.

hospital stay (LOS >2 d: 64% in the scheduled hospital stay group vs. 26.6% in the unscheduled hospital stay group) (Prevost et al., 2023). The results of Riekert et al. showed that early extubation led to a shorter LOS (7.11 vs 8.10; p = 0.023) (Riekert et al., 2019). The results of the other studies show that neither surgical site infection (Naros et al., 2023), nor preanesthetic medications (Kim et al., 2015) or blood

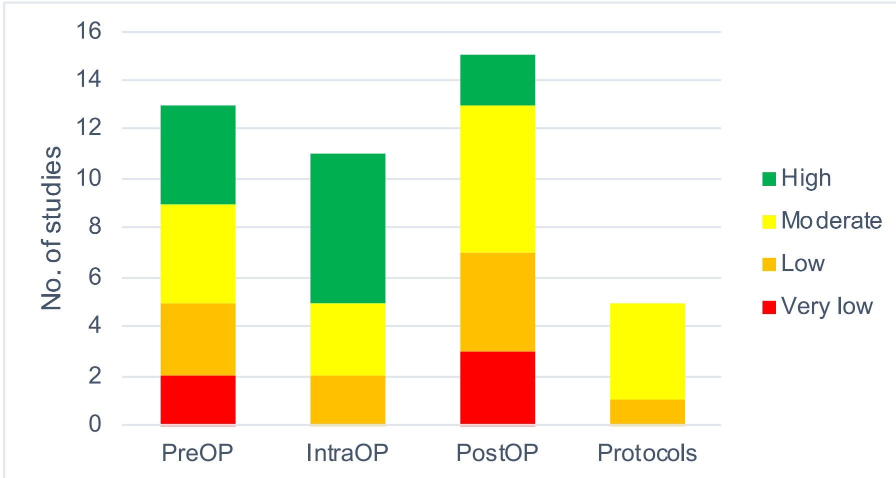


Fig. 3. Overview of GRADE divided into pre-, intra-, postoperative ERAS elements and protocols.

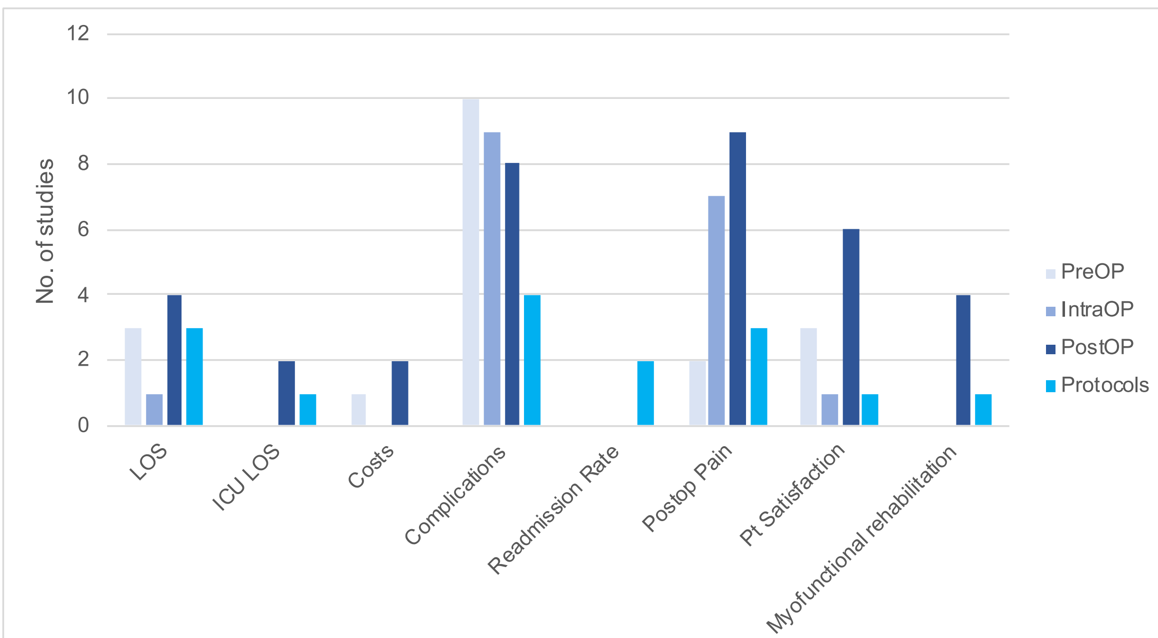


Fig. 4. Overview of outcomes divided into pre-, intra-, postoperative ERAS elements and protocol.

management (Fenner et al., 2009; Lee et al., 2020) have an impact on LOS. A study of patient satisfaction by Kim et al. found that 88.7% of patients found a hospital stay of 6–8 days acceptable. 11.3% thought it was much too long (Kim et al., 2009).

3.7. ICU LOS

Only three studies reported ICU LOS. Riekert et al. showed a significantly shorter ICU LOS associated with early extubation (1.05 vs. 2.28; $p \leq 0.001$) (Riekert et al., 2019). In the prospective outpatient study by Prevost et al. no patients required ICU admission and the results of the protocol by Wahlstrom et al. showed no difference in ICU LOS between ERAS and control group (126 vs. 106 min, $p > 0.05$) (Prevost et al., 2023; Wahlstrom et al., 2023).

3.8. Costs

None of the interventions quantifies economic advantages or disadvantages. Information on health economic aspects was only provided by three studies with low to very low evidence. Rummasak et al. reported that the cost of preoperative autologous blood donation (PABD) was two times more expensive than of a donor blood transfusion and that over-ordering of blood is inappropriate due to the generally very low transfusion rates (2.4%) and economic burden (amount of blood wasted and laboratory workload) (Rummasak et al., 2011). A study of swelling and pain prevention using Hilotherm reported a weekly rental cost of £105-£165 for home care (Mahendran et al., 2022). Patient satisfaction evaluation in Korea showed that 84.1% of patients thought the treatment was too expensive (Kim et al., 2009).

3.9. Complications

In 31 studies of postoperative complications, nine reported PONV (one also reported PDNV), seven reported surgical procedure-related events, five reported infections, four reported the need for blood transfusion, one reported adverse drug reactions, and eight reported no relevant complications. Only Riekert et al. used the Clavien-Dindo (CD) classification, noted 30 minor (CD I-II) and eight major (CD III-IV) complications. Infection rates ranged from 1.64% to 35.4% (Jansisyanont et al., 2008; Tan et al., 2011; Riekert et al., 2019; Naros et al., 2023). Antibiotic choice and duration had no effect on infection rates, so there is a consensus that a single dose appears to be sufficient (Baqain et al., 2004; Jansisyanont et al., 2008; Tan et al., 2011; Eshghpour et al., 2014; Riekert et al., 2019; Naros et al., 2023). Baqain et al. showed only a higher morbidity score and increased swelling in the short-term group (both $p = 0.04$) (Baqain et al., 2004). Antiemetic protocols by Wahlstrom et al. and Brookes et al. significantly reduced PONV (Brookes et al., 2015; Wahlstrom et al., 2023), but didn't prevent PDNV (Brookes et al., 2015). In the study by Prevost et al., PONV was the most common reason for hospital admission among patients scheduled for outpatient treatment (PONV incidence 38.1%) (Prevost et al., 2023). No advantage of PONV based on anesthetic agents was observed (Caverni et al., 2005; Chegini et al., 2012; Tabrizi et al., 2012), but it correlated with Apfel score (OR 1.8; $p = 0.03$) (Bertuit et al., 2021) and surgery duration ($p = 0.01$). Tabrizi et al. showed that with increasing duration over 165 min, 89% of patients experienced PONV (Tabrizi et al., 2012). Pharyngeal packing soaked with chlorhexidine/benzydamine tended to reduce the incidence of PONV, although this was not significant (Vural et al., 2019).

3.10. Readmission rate

Only two studies, specifically those implementing multidisciplinary ERAS protocols, reported readmission rates. Ferrara et al. showed no difference between the groups. Both the ERAS and control group had one readmission for postoperative bleeding within one week following surgery (Ferrara et al., 2022). Hattori et al. recorded no emergency hospitalizations or readmissions within 48 h of discharge (Hattori et al., 2023).

3.11. Postoperative pain

21 studies reported postoperative pain, of which 11 reported VAS pain scores. In the studies with protocols, the intervention groups showed effective pain reduction compared to the control group, especially in the early postoperative phase (14 days) (Oliveira et al., 2021) and at maximum pain levels (maximum pain 5.5 vs. 7.5; $p < 0.001$) (Wahlstrom et al., 2023), with significantly reduced opioid consumption in the PACU (55% vs. 67.1%; $p < 0.01$) (Ferrara et al., 2022). Only two protocols, by Ferrara et al. and Wahlstrom et al., adopted multimodal perioperative analgesia (Ferrara et al., 2022; Wahlstrom et al., 2023). Hattori et al.'s protocol provided postoperative analgesia with NSAIDs only when required (Hattori et al., 2023), and Brookes et al. described a stepwise regimen with opioids (Brookes et al., 2015). No study explicitly addressed the benefit of multimodal postoperative analgesia.

The single interventions (or "elements") with a positive effect on pain perception compared to controls include preoperative (Tuzuner et al., 2007) and intraoperative multimodal analgesia, although only in the early phase (postoperative pain intensity at rest (POPI) in the PACU 1 h after extubation) (Nagatsuka et al., 2000), perioperative melatonin prophylaxis (Lee and Curtin, 2020), block anesthesia (incidence 4. 0% vs 22.8%; $p < 0.01$), low laser level therapy (LLL) (compared to published values) (Miloro and Repasky, 2000) and chlorhexidine/benzydamine soaked throat packing (regarding throat pain, no difference regarding surgical pain) (Vural et al., 2019). Transcutaneous electrical nerve stimulation (TENS) (Cacho et al., 2022), circadian time of recovery from anesthesia (Park et al., 2015), the choice of hypotensive drug (Rummasak and Apipan, 2014) or antibiotic (Baqain et al., 2004; Tan et al., 2011) had no benefit on pain perception. The results regarding the anesthetics used (TIVA vs. volatile agents) were inconsistent (Caverni et al., 2005; Chegini et al., 2012; Tabrizi et al., 2012).

3.12. Patient satisfaction

11 studies assessed patient satisfaction, with great heterogeneity in terms of the evidence, assessment tools, and interventions. Patients with SSRO (vs IVRO) and surgery first (vs traditional sequence) benefit earlier due to shorter treatment duration and earlier psychological benefits (Beccuti et al., 2022; Wong and Leung, 2023). Patient education generally showed high levels of satisfaction (Li et al., 2018b; Sousa and Turrini, 2019). Phillips et al. found psychological distress associated with higher expectations of postoperative problems and higher expected treatment benefits, regardless of preparation strategy (Phillips et al., 2001). Oliveira et al.'s myofunctional rehabilitation showed no difference in OHIP-14 compared to control (Oliveira et al., 2021).

Kim et al. showed that patients were dissatisfied with overall length of treatment, Foley catheterization, hypertrophy due to transbuccal trocars and hospital administration complexity (Kim et al., 2009). In addition, use of Hilotherm was found to be very comfortable (Mahendran et al., 2022), patients were very satisfied with preoperative analgesia (no statistical differences between groups) (Tuzuner et al., 2007) and inhalation of nebulized hyaluronic acid resulted in a significant improvement in the I-nose score (Bergonzani et al., 2022).

3.13. Additional outcomes

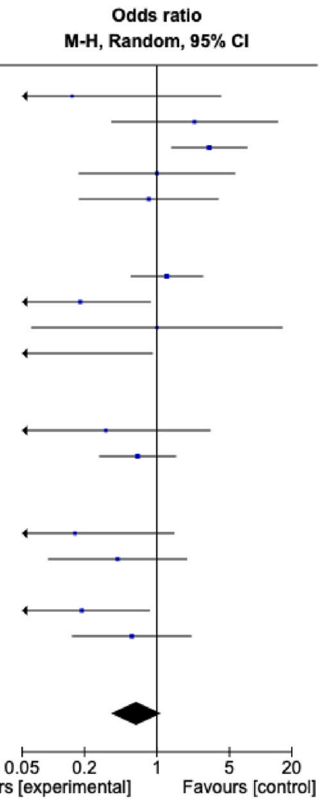
Surgery-specific outcomes relate primarily to myofunctional and neurosensory rehabilitation. These studies showed significant improvements, particularly in the early postoperative period, and reduced recovery duration compared to control groups (Miloro and Repasky, 2000; Ko et al., 2015; Teng et al., 2015; Lee and Curtin, 2020; Cacho et al., 2022). Early physiotherapy showed significant improvements in myoelectrical activity of masticatory muscles and mandibular motion range in the first 6 weeks after OGS (Ko et al., 2015; Teng et al., 2015). Weekly TENS application significantly increased jaw opening (especially in class II: 7 mm more compared to control group after 4 weeks; $p = 0.012$) and accelerated swelling reduction (Cacho et al., 2022). Watanabe et al. showed a trend towards improved maximum bite force and significantly higher masticatory performance with training foods, although the evidence was very weak (Watanabe et al., 2022). The protocol by Oliveira et al. showed significant improvements in mandibular movement and swelling over time, with comparable results between groups. Masticatory efficiency tended to be better in the training group without reaching statistical significance (Oliveira et al., 2021). Perioperative LLL and melatonin treatment significantly improved neurosensory recovery (Miloro and Repasky, 2000; Lee and Curtin, 2020). Lee&Curtin observed a 30% reduction in subjective numbness at week one, increased to over 80% at three months postoperatively ($p < 0.00001$). Objective neurosensory testing showed a significantly improved healing profile in the melatonin group, with lower hydrogen peroxide levels ($p < 0.00001$) and higher antioxidant enzymes ($p < 0.00001$) postoperatively (Lee and Curtin, 2020). Preoperative steroid prophylaxis significantly reduced postoperative oedema, especially in the first 2 weeks, without causing any adverse effects (Abukawa et al., 2017; Semper-Hogg et al., 2017).

3.14. Meta-analysis of complications, length of stay, and pain

Out of the 31 studies that reported postoperative complications, 23 were included in the meta-analysis. Eight of these studies reported no complications in either the intervention group or the control group. When compared to conventional care, patients OGS following an ERAS protocol or elements that could be part of a future ERAS protocol were approximately 37% less likely to develop complications. However, this difference was not statistically significant (OR 0.63, 95% CI 0.36–1.10, $p = 0.10$, $I^2 = 50\%$, Fig. 5).

Of the 11 studies that reported on LOS, five were included in the meta-analysis. The ERAS group ($n = 318$) had a shorter hospital stay

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Odds ratio M-H, Random, 95% CI
Abukawa 2017	0	16	1	8	2.4%	0.15 [0.01 , 4.17]
Baqain 2004	4	17	2	17	5.7%	2.31 [0.36 , 14.72]
Bertuit 2021	23	50	12	57	11.4%	3.19 [1.37 , 7.44]
Caverni 2005	2	40	4	80	6.2%	1.00 [0.18 , 5.71]
Chegini 2012	3	21	5	30	7.0%	0.83 [0.18 , 3.94]
Eftekharian 2015	0	28	0	28		Not estimable
Eshghpour 2014	0	25	0	25		Not estimable
Ferrara 2022	15	189	11	170	11.7%	1.25 [0.56 , 2.79]
Goswami 2021	4	15	10	15	7.0%	0.18 [0.04 , 0.87]
Jansisyanont 2008	1	61	1	61	3.2%	1.00 [0.06 , 16.36]
Kim 2015	0	48	4	24	2.9%	0.05 [0.00 , 0.91]
Ko 2015	0	31	0	32		Not estimable
Lee & Curtin 2020	0	15	0	15		Not estimable
Lee 2020	1	28	3	29	4.2%	0.32 [0.03 , 3.29]
Riekert 2019	10	38	28	79	11.3%	0.65 [0.28 , 1.53]
Rummasak & Apipan 2014	0	20	0	20		Not estimable
Semper-Hogg 2017	0	21	0	17		Not estimable
Tabrizi 2012	1	32	5	30	4.5%	0.16 [0.02 , 1.47]
Tan 2011	3	21	6	21	7.1%	0.42 [0.09 , 1.96]
Teng 2015	0	31	0	32		Not estimable
Tuzuner 2007	5	24	7	12	7.2%	0.19 [0.04 , 0.85]
Vural 2019	4	53	6	48	8.2%	0.57 [0.15 , 2.16]
Wahlstrom 2023	0	79	0	103		Not estimable
Total (95% CI)		**903**		**953**	**100.0%**	**0.63 [0.36 , 1.10]**
Total events:	76		105			



Heterogeneity: Tau² = 0.53; Chi² = 28.05, df = 14 (P = 0.01); I² = 50%
Test for overall effect: Z = 1.64 (P = 0.10)
Test for subgroup differences: Not applicable

Fig. 5. Forest plot comparing complications between ERAS and the control group.

compared to the control group (n = 316). The mean difference was −0.41 days (95% CI -0.88 to 0.07) in favor of patients following ERAS protocols or elements that could be incorporated into a future ERAS protocol, but this difference was not statistically significant (p = 0.10, Fig. 6). Heterogeneity was very high ($I^2 = 92\%$).

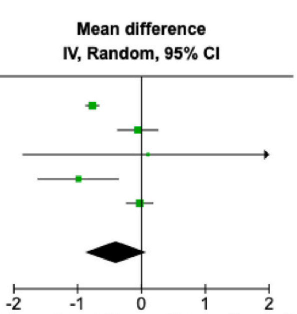
Six out of the 21 studies that looked at postoperative pain were analyzed in a meta-analysis. Two studies reported pain using medians (Nagatsuka et al., 2000; Tuzuner et al., 2007). To calculate means and standard deviations, the method described by Hozo et al. was used (Hozo et al., 2005). The meta-analysis revealed that patients undergoing OGS and following an ERAS protocol or elements that could be part of a future ERAS protocol experienced significantly less postoperative pain compared to the control group. The overall mean difference in pain scores was −1.77 (95% CI -2.30 to −1.24, p < 0.00001, Fig. 7). The level of variation among the studies (heterogeneity) was low, at 18%.

4. Discussion

To our knowledge, this work is the first synopsis of existing ERAS- and multimodal protocols, as well as perioperative elements in the care of patients undergoing OGS. The identified elements were also analyzed for the first time according to ERAS-typical outcome criteria and the evidence of the studies was assessed according to the GRADE approach. Additionally, a meta-analysis was conducted to quantitatively evaluate the impact of these protocols and elements on complications, LOS, and postoperative pain compared to conventional perioperative care strategies. Therefore, this study provides a comprehensive overview of evidence-based care elements in OGS, extending beyond ERAS, and can serve as a foundation for the development of a comprehensive evidence-based ERAS protocol.

In total, 44 studies were included in the qualitative synthesis, identifying a total of 49 elements of perioperative care (13 pre-, 15 intra-, and 21 postoperative). Thirty-nine studies investigated single elements (13 pre-, 11 intra-, and 15 postoperative), with some having the potential, due to their high evidence, to be included in a subsequent comprehensive ERAS protocol with a strong recommendation. Notably, antimicrobial and steroid prophylaxis, PONV prevention, and standardized anesthesia with the avoidance of long-acting opioids were

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, Random, 95% CI
Ferrara 2022	0.65	0.38	189	1.42	0.63	170	26.8%	-0.77 [-0.88 , -0.66]
Kim 2015	3.3	0.56	48	3.36	0.7	24	24.2%	-0.06 [-0.38 , 0.26]
Lee & Curtin 2020	4.9	3.2	15	4.8	2.2	15	4.9%	0.10 [-1.87 , 2.07]
Riekert 2019	7.11	1.06	38	8.1	2.45	79	18.3%	-0.99 [-1.63 , -0.35]
Wahlstrom 2023	1.04	0.47	28	1.07	0.33	28	25.8%	-0.03 [-0.24 , 0.18]
Total (95% CI)			**318**			**316**	**100.0%**	**-0.41 [-0.88 , 0.07]**



Heterogeneity: Tau² = 0.22; Chi² = 49.41, df = 4 (P < 0.00001); I² = 92%
Test for overall effect: Z = 1.66 (P = 0.10)
Test for subgroup differences: Not applicable

Fig. 6. Forest plot comparing length of stay between ERAS and the control group.

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean difference IV, Random, 95% CI
Lee & Curtin 2020	3.5	1.86	15	6.5	3.46	15	6.7%	-3.00 [-4.99 , -1.01]
Nagatsuka 2000	5	2.2	41	6.2	2.6	41	20.3%	-1.20 [-2.24 , -0.16]
Rummasak & Apipan 2014	4.05	2.54	20	4.8	2.59	20	10.0%	-0.75 [-2.34 , 0.84]
Tuzuner 2007	4	1.47	24	6.5	1.7	12	18.0%	-2.50 [-3.63 , -1.37]
Vural 2019	2.5	2.13	53	4.1	2.55	48	24.5%	-1.60 [-2.52 , -0.68]
Wahlstrom 2023	5.5	2.2	28	7.5	1.73	28	20.5%	-2.00 [-3.04 , -0.96]
Total (95% CI)			**181**			**164**	**100.0%**	**-1.77 [-2.30 , -1.24]**

Heterogeneity: Tau² = 0.08; Chi² = 6.13, df = 5 (P = 0.29); I² = 18%
Test for overall effect: Z = 6.50 (P < 0.00001)
Test for subgroup differences: Not applicable

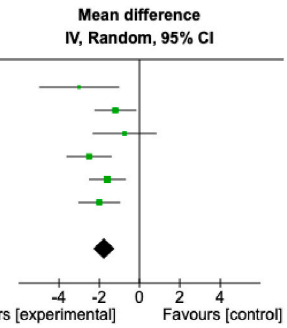


Fig. 7. Forest plot comparing pain between ERAS and the control group.

among these elements.

Surprisingly, of the five protocols found, only three were related to ERAS, and of these only two were multidisciplinary, including both surgical and anesthetic aspects. None of these protocols included nursing. As they were developed by the authors or the medical institutions themselves, questions arise about the evidence and validity of these protocols. While there is significant room for improvement to be considered comprehensive, well-structured ERAS protocols, they undoubtedly represent a crucial first step in the right direction.

Continuous evaluation of clinical practice and outcomes is a crucial component of continuous quality improvement in healthcare (Wainwright et al., 2020). Measures such as measuring clinical outcomes (e.g., LOS, readmissions, and complications), non-clinical outcomes (e.g., cost-effectiveness, patient satisfaction/experience), compliance with ERAS components in processes, as well as audit and feedback, form the backbone of an effective ERAS programme. While challenging to implement, when executed correctly, these measures lead to better outcomes, fewer complications, and ultimately, shorter hospital LOS and reduced hospital costs. However, it is important to note that no study in the field of OGS has incorporated the basic principles of ERAS (measurement, audit and feedback). This represents a good opportunity to apply the knowledge and continuous development of ERAS over the past 23 years, with proven benefits for patient care, to OGS and ultimately to other procedures in OMFS.

Colorectal surgery is the cradle for ERAS development and continues to dominate the literature (Ljungqvist et al., 2017b). In this field, outcome parameters are well established and can serve as a model for OGS. Studies have shown that applying ERAS principles can reduce LOS (Bardram et al., 1995; Kehlet and Mogensen, 1999; Delaney et al., 2001; Senagore et al., 2001) and complication rates by up to 50% (Varadhan et al., 2010; Greco et al., 2014). Implementation of the ERAS colorectal programme in the state health care system of Alberta (Canada), yielded a financial benefit of $2800 to $5900 per patient, along with a reduced hospital stay (from 6 to 4.5 days), an 11% decrease in complication rates, and 8% fewer readmissions (Nelson et al., 2016). Similarly, this review demonstrated a significantly shorter LOS in the two studies with ERAS protocols (86.8–99.3% discharged on the same day with a maximum overnight stay, compared to an average of 3–8 days) (Riekert et al., 2019; Ferrara et al., 2022; Hattori et al., 2023). It should be noted that the aim of both protocols was also to reduce the length of hospitalization and, in the case of Ferrara et al., to reduce the use of opioids. The meta-analysis of LOS also indicated a shorter hospital stay for the ERAS group compared to the control group, although this difference was not statistically significant (mean difference −0.41 days, 95% CI -0.88 to 0.07, $p = 0.10$).

The results of this review highlight the heterogeneity of the research landscape for OGS concerning the examined outcome parameters. Complications (38%, 31 studies) and postoperative pain (26%, 21 studies) were the most commonly investigated outcomes, mainly in studies with high evidence. LOS and patient satisfaction were each assessed in 11 studies (13%), with predominantly low to moderate evidence. Low evidence was found for ICU length of stay, health care costs (4% each, 3 studies), and readmission rates (2%, 2 studies). Here, OGS has procedure-specific characteristics. Certainly, readmission rates are very low (0–0.55% in both studies) and it is debatable whether this outcome is relevant for OGS. On the other hand, LOS, ICU LOS and consequently healthcare costs also play an important role in OGS and should receive more attention in future studies. Another under-reported outcome with highly inconsistent results is patient satisfaction. The introduction of patient-reported outcome measures (PROMs) may lead to more valid results in this regard.

The decision to integrate elements of myofunctional and neurosensory rehabilitation into an ERAS protocol should be the task of an expert panel. OGS is primarily a function-improving procedure, similar to knee and hip surgery in orthopedics, where preoperative physiotherapy or surgical techniques are discussed in the ERAS guidelines (Wainwright et al., 2020). Another argument supporting the consideration of these elements for inclusion in a protocol is the finding from the study by Mottura, emphasizing that intensive postoperative care, including daily support from staff, accelerates recovery and provides patients with a positive and well-supported experience. This contrasts with the traditional approach of allowing recovery to occur naturally, and highlights the positive impact of staff involvement on the healing process, patient well-being and satisfaction (Mottura, 2002).

Oliveira et al. exclusively focused on an interdisciplinary myofunctional rehabilitation protocol involving early specialized exercises and lymphatic drainage with speech therapists. Interestingly, the intervention group only showed significant improvement in pain perception in the early phase, without observing functional improvement (Oliveira et al., 2021). The review indicates that all identified interventions positively impacted neurosensory and functional rehabilitation, along with the timeline, minimizing pain, especially in the first 14 days to 6 weeks postoperatively (Miloro and Repasky, 2000; Ko et al., 2015; Teng et al., 2015; Lee and Curtin, 2020; Oliveira et al., 2021; Cacho et al., 2022; Watanabe et al., 2022). However, it is essential to note that most of these studies have a low level of evidence and, in some cases, include very small patient populations, emphasizing the need for further high-quality studies. The same applies to patient education, where although results suggest improved satisfaction, a preferred method cannot be recommended based on current evidence.

There is a need for improvement and mandatory standardization of perioperative and especially postoperative multimodal analgesia. In general, postoperative analgesia was treated very differently in the protocols. For example, it is surprising that Hattori et al. prescribed NSAIDs only as needed in their ERAS protocol (Hattori et al., 2023). While, other authors used stepwise approaches with substantial differences. Brookes et al. used a stepwise approach with opioids and after conversion to oral analgesics, only ibuprofen was administered (Brookes et al., 2015). Only Wahlstrom et al. (NSAID and paracetamol) and Ferrara et al. (through the combination drug Hycet) used multimodal combinations of different analgesic classes in the first stage (Ferrara et al., 2022; Wahlstrom et al., 2023). However, the meta-analysis of pain for all interventions showed that patients who followed an ERAS protocol or elements that could be incorporated into a future ERAS protocol had significantly less postoperative pain compared to the control group (mean difference −1.77, 95% CI -2.30 to −1.24, $p < 0.00001$).

The goal of multimodal analgesia is to achieve high-quality pain control (<4 on the VAS) while reducing the use of opioids. This reduction in opioids contributes to improving PONV, a major cause of delayed recovery and prolonged hospital stay. Multimodal analgesia in OGS should be supported by further studies and become an essential part of future ERAS protocols for OGS.

Only a few participants in the surgical care pathway have the opportunity to accompany a patient throughout their entire journey. Future core elements of ERAS care are distributed along the patient pathway and are provided by various departments and professionals within the hospital (surgery, anesthesia, nursing). Therefore, it is advisable that the surgeon, as the clinician with overall responsibility for the patient, has the best opportunity to steer the process from a comprehensive perspective. This should be taken into account when planning further steps (Ljungqvist et al., 2017a).

This review provides a comprehensive overview of perioperative care elements published in the last 23 years in the field of OGS, including efficacy, safety and impact on perioperative outcomes, compared to conventional perioperative care strategies. The available OGS-ERAS studies are limited and provide low to moderate evidence of improved outcomes. Furthermore, none of the protocols completely meet the ERAS recommendations (surgery, anesthesia, nursing). RCTs with comprehensive ERAS protocols and recording of ERAS-typical outcomes would provide a better understanding of their impact on perioperative outcomes.

Limitations of this review include the expectation of a limited number of RCTs comparing ERAS protocols with conventional care strategies, resulting in a low inclusion threshold for studies and thus limiting the conclusions that could be drawn from some studies. Although a quantitative data synthesis in the form of a meta-analysis for complications, LOS, and postoperative pain was performed, the heterogeneity of studies and inconsistent reporting of results posed a major challenge. The meta-analysis found significant results in some areas, but overall conclusions were limited by variability in study design and outcome measures. Despite a comprehensive systematic search that included all relevant terms related to ERAS-specific interventions in the context of OGS, potential process improvements may have been overlooked because the relevant publications were not published as part of an ERAS, rapid recovery or fast-track surgery protocol.

5. Conclusion

In conclusion, this systematic review provides the first synopsis of ERAS elements to optimize perioperative patient care in OGS and includes the first meta-analysis evaluating the impact of available ERAS protocols and elements that could be incorporated into a future ERAS protocol compared with conventional care. Complete ERAS protocols, as seen in other surgical disciplines, are not established in OMFS, particularly in OGS. There is a relatively large number of studies on postoperative care, with a low level of evidence. Few studies with low evidence on pre- and intraoperative elements are surgically focused. Relatively strong evidence is found for the intraoperative anesthesiological intervention areas. The outcome parameters are often not “hard” criteria, but inhomogeneous surrogate parameters. In particular, the preoperative and postoperative phases, require further investigation in clinical studies. Based on the identified evidence, the next step should be the development of a comprehensive protocol via a consensus conference, followed by implementation in clinical practice.

Conflict of interest

All authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

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