

Systematic Review

Maxilla-first versus mandible-first in bimaxillary orthognathic surgery: a systematic review

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Abstract – Introduction: For the great majority of surgeons, orthognathic bimaxillary surgery requires one jaw to be osteosynthesized before repositioning the second jaw. Sequence of bimaxillary surgery between maxilla-first or mandible-first is source of controversy regarding results accuracy in relation to treatment plan. This systematic review aims to compare bimaxillary surgery occlusal, skeletal results and planning conformity according to surgical sequence. **Material and methods:** This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Three electronic databases were searched in June 2023. Clinical trials and observational studies on patients who underwent bimaxillary surgery as part of orthodontic treatment were included. Inclusion eligibility screening, data extraction and risk of bias assessment were performed independently in duplicate. **Results:** Eight articles were included. There was no consensus in the accuracy of the results in transversal, sagittal or vertical dimensions. Some clinical conditions seemed to be more suitable for one or other of surgical sequences. **Conclusion:** This review enabled to propose decision criteria for most appropriate sequence depending on clinical conditions in orthognathic. Given the moderate risk of bias of the majority of included studies, careful data interpretation is needed and future studies of higher quality are recommended.

Introduction

Orthognathic surgery is indicated to treat skeletal class II and III, dento-maxillofacial disorders and maxillofacial asymmetries [1].

Factors determining the success of orthognathic surgery are an accurate diagnosis, an appropriate treatment plan, surgical reproduction of that treatment plan and postoperative stability. For the great majority of surgeons, orthognathic bimaxillary surgery requires one jaw to be repositioned and osteosynthesis performed before the second jaw repositioning [2]. The surgical sequence of bimaxillary surgery between maxilla-first or mandible-first is source of controversy regarding the accuracy of surgical results in relation to treatment plan [3].

In the age of internal wire fixation, maxilla was the only jaw that could be sufficiently stable. Maxilla was therefore first repositioned and stabilized in bimaxillary osteotomies, thus explaining the traditional maxilla-first approach, which is still

very common today [4]. Lindorf and Steinhäuser were the first to publish a mandible-first surgical protocol in 1978 [5].

Only one systematic review has assessed the current knowledge of advantages of mandible-first in orthognathic bimaxillary surgery with a majority of case reports [6]. No review has considered the difference in results between maxilla-first and mandible-first.

This systematic review aims to compare the occlusal and skeletal results and planning conformity of bimaxillary surgery according to the surgical sequence: maxilla-first versus mandible-first.

Materials and methods

Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [7]. Review protocol was registered at PROSPERO under the unique number CRD42023451644. Details of the protocol can be found at <https://www.crd.york.ac.uk/prospéro/>.

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Eligibility criteria

Eligibility criteria were predefined, based on the aim of the study. Studies on patients who underwent bimaxillary orthognathic surgery as part of orthodontic treatment, randomized and non-randomized clinical trials, prospective or retrospective observational studies, publications in English or French were considered eligible.

Studies involving patients who had not been treated with orthognathic surgery or who had undergone isolated maxillary or mandibular osteotomy were excluded.

Information sources and search strategy

The research question was “Which surgical sequence in bimaxillary orthognathic surgery provides the best occlusal and skeletal results according to the planning?”. It was defined using the Patient, Intervention, Comparison, Outcome (PICO) method:

- Procedure: bimaxillary orthognathic surgery;
- Intervention: maxillary osteotomy first then mandibular osteotomy;
- Comparison: mandibular osteotomy first then maxillary osteotomy;
- Outcome: occlusal and skeletal result as planned.

Three electronic databases were searched: PubMed, Scopus and Cochrane Library. The search terms were developed for PubMed: (orthognat* OR bimax* surg* OR bimax* osteotom* OR double-jaw* surg* OR double-jaw* osteotom*) AND (maxil* first AND/OR mandib* first OR sequenc*). Search terms were modified for the other databases: (sequence AND (orthognathic OR bimaxillary) AND ('surgery'/exp OR surgery)). Filters were used to select only articles in English and French. No date restriction was applied. Additionally, a hand search of the bibliographic references of the electronic search included articles was performed to complete the selection. Bibliographic references were managed using Zotero software (version 6.0.26). Literature search was conducted in August 2023, and may include articles published until 31st August 2023.

Study selection

Two investigators were involved in the study selection process (M.F. and E.M.R.). Articles inclusion, as defined by the eligibility criteria established previously, was carried out at each step of reading the title, abstract and full text. Initial search yielded an initial identification list (list 1). After removal of duplicates and reading titles and abstracts, the second selection list was drawn up (list 2). Third eligibility list (list 3) was obtained after a complete reading of the articles. Final inclusion list (list 4) was obtained after a manual search based on selected articles bibliography. Disagreement regarding any inclusion was solved by consulting a third investigator (P.L.).

Data items and collection

Data extraction was performed independently by two researchers (M.F. and E.M.R.). Any differences between the two investigators were solved by consulting a third researcher (P.L.). Data extraction included: study identification (authors name, publication year, country), aim of the study, methods (study design, data collection, planning protocol, intervention sequence, measurements), population (sample size, gender, mean age, type of dysmorphosis), surgery-related factors (operating time, osteosynthesis revision, occurrence of intra and/or postoperative complications), immediate skeletal and occlusal results (compliance or otherwise and accuracy between planning and surgery), follow-up time and outcome. Extracted data were collected in an excel spreadsheet. Authors were contacted if the information was lacking.

The level of evidence of the studies was based on the classification of the National Health and Medical Research Council [8].

Risk of bias assessment

To evaluate the risk of bias, two observers (M.F. and E.M.R.) evaluated the studies independently. These assessments were conducted with validated instruments: Risk Of Bias In Non-randomized Studies – of Interventions (ROBINS-I) tool was applied to assess risk of bias of cohort studies [9] and Risk of Bias 2 (RoB 2) tool was used for randomized trials [10]. Any disagreement between the observers were discussed and resolved by consensus.

Results

Study selection and characteristics

Selection process is presented in [Figure 1](#). Seven hundred and forty-four articles were identified through database searching (PubMed $N=653$, Scopus $N=82$, Cochrane Library $N=9$). After title reading and duplicate removal, 17 articles underwent abstract screening and 8 articles underwent full-text screening. No article was included through hand search. A remaining of eight articles met the eligibility criteria of this review. Main characteristics of the included articles are presented in [Table I](#).

Results of individual studies

Data were extracted from the articles and summarized in [Table II](#), while missing data could not be completed as the authors did not reply to the emails sent.

Synthesis of the results

According to the articles included in this review, maxilla-first sequence should be preferred for maxillary vertical excess treatment [13] as well as in case of maxillo-mandibular

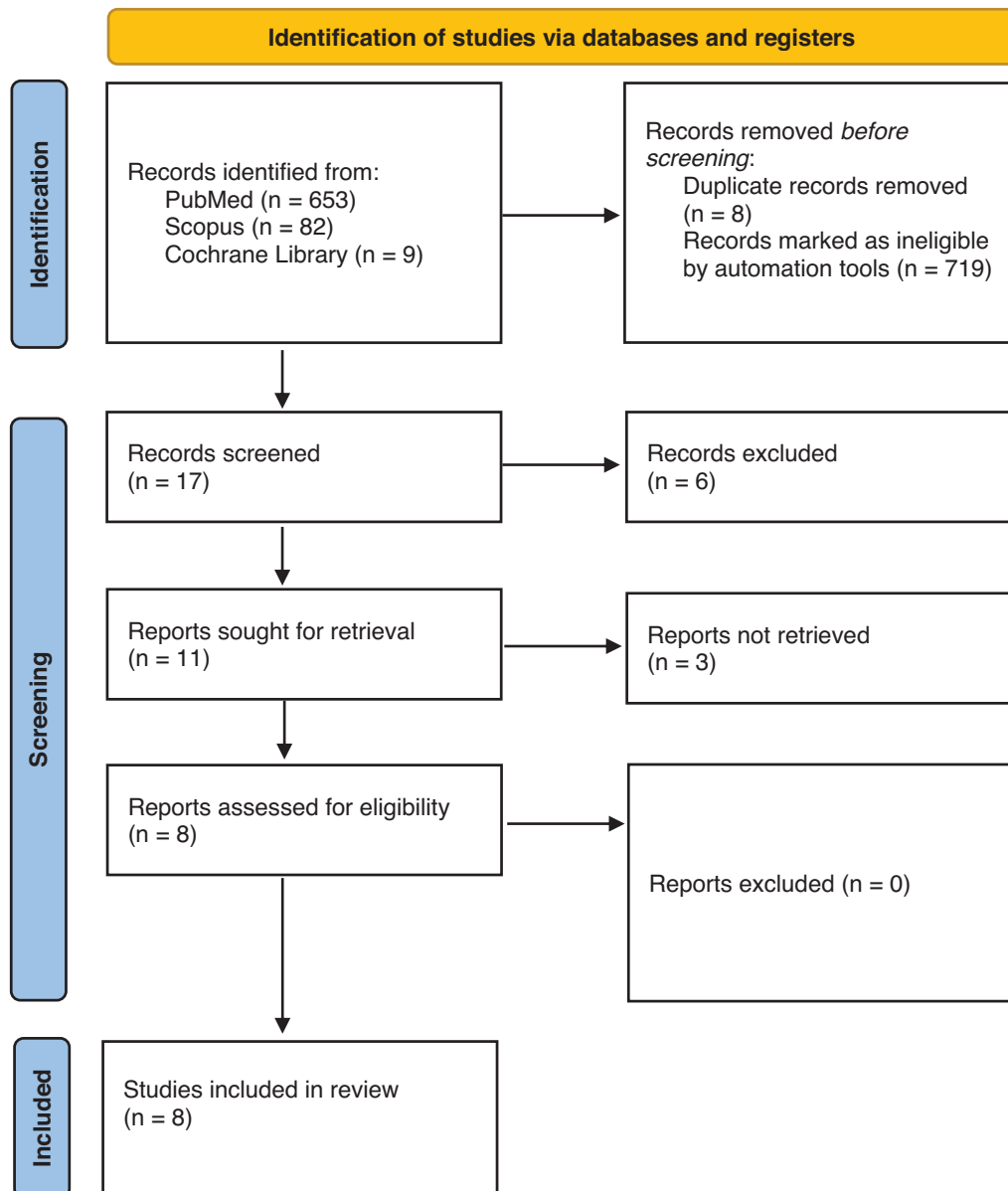


Fig. 1. Flow chart of the systematic review.

complex clockwise surgical rotation movement [15]. Mandible-first sequence would be recommended in the case of surgical maxilla-mandibular complex counter-clockwise rotation [15].

There did not appear to be any influence of the surgical sequence on results in transverse dimension [11,16]. Concerning the vertical dimension, there was no consensus, with some studies reporting no significant difference [4] and others stating there was a difference either in favor of the maxilla or the mandible-first sequence [13,15,16]. In the sagittal dimension, results appeared to be slightly more accurate for maxilla-first sequence [11,12] with some studies reporting no significant difference [4,16]. Splint thickness did not appear to influence the results.

The studies included in this review showed malocclusions recurrence, regardless of the surgical sequence [14,17].

Risk of bias assessment

Overall, according to ROBINS-I tool, two studies were judged to be “low risk”, four as “moderate risk” and one as “severe risk” of bias. The tabular representation of risk of bias assessment using ROBINS-I tool are represented in Table III.

According to RoB 2 tool, the randomized clinical trial included was at “low risk” of bias (Tab. IV).

Discussion

Mandible-first sequence is much less documented in the scientific literature than maxilla-first.

A systematic review was published in 2016, which investigated decision criteria in favor or mandible-first

Table I. Main characteristics of the included articles.

Year of publication	Author	Sources	Type of study (level of evidence)	Country of publication
2009	Beziat <i>et al.</i> [11]	PubMed, Scopus	Prospective cohort study (grade III-2)	France
2014	Ritto <i>et al.</i> [4]	PubMed, Scopus	Retrospective cohort study (grade III-2)	Brazil
2017	Liebrechts <i>et al.</i> [12]	PubMed, Scopus	Retrospective cohort study (grade III-2)	Netherlands
2018	Salmen <i>et al.</i> [13]	PubMed, Scopus	Retrospective cohort study (grade III-2)	Brazil
2019	Liebrechts <i>et al.</i> [14]	PubMed, Scopus	Retrospective cohort study (grade III-2)	Netherlands
2019	Stokbro <i>et al.</i> [15]	PubMed, Scopus	Retrospective cohort study (grade III-2)	Danemark
2021	Borikanphanitphaisan <i>et al.</i> [16]	PubMed, Scopus	Retrospective cohort study (grade III-2)	Taiwan
2021	Hamdy and Elfaramawi [17]	PubMed, Scopus, Cochrane	Randomized clinical trial (grade II)	Egypt

sequence. It was based on 5 case reports and a cohort study, the latter was also included in our review. The authors concluded there were theoretical advantages to performing a mandible-first sequence, but that in practice it was the surgeon's experience and preference that determined the operative sequence of bimaxillary surgery [6]. Our review was therefore complementary in that it provided new information on surgical results in three dimensions and on the stability of the results as factors that could influence the choice of surgical sequence.

Summary of evidence and additional information from the literature

Table V summarizes the decision criteria for the surgical sequence in bimaxillary surgery, based on the conclusions of our systematic review and supplemented by data from the literature.

Surgery planning

Regarding to centric relation recording, Cottrell and Wolford's main argument for performing mandible-first was better prediction of final occlusion, as this method eliminates the errors associated with centric relation recording on the models used for planning [20]. Posnick *et al.* reinforced these arguments by stating that in cases where there was no reliable centric relation, planning should begin with maxilla and surgery with mandible [18]. No data concerning centric relation registration was found in our review.

Regarding to intermediate splint design, rotation of occlusal plane had the drawback of resulting on significant open bites, requiring the use of very thick splints. In the case of surgical maxillo-mandibular complex clockwise rotation, maxilla-first seemed to be most appropriate and mandible-first

in case of counter-clockwise rotation [1,19]. Perez and Ellis stated it was more appropriate to use mandible-first sequence in case of thick intermediate splint [2,19]. In our review, only one article reported that the splint thickness had no effect on the results whatever the surgical sequence [16].

In our review, the type of planning (articulator versus digital) did not seem to indicate more one of the two operating sequences. No data was found in the literature concerning the type of planning.

Surgical indication and type of surgical movement

Authors agreed that a maxilla-first sequence should be performed in cases of surgical clockwise rotation to close an anterior open bite with posterior impaction and/or maxillary anterior lowering. These movements create a posterior open bite that will be corrected after BSSO. A mandible-first would significantly increase the open bite and would require a very thick anterior splint, complicating intermaxillary blocking. In contrast, in the case of occlusal plane counter-clockwise rotation, mandible-first was most frequently described [1,2]. This was also reported in our systematic review [15].

Several authors have suggested that mandible-first sequence should be carried out in the case of maxillary segmentation [18,19], whereas maxillary primary procedures are indicated in the case of non-segmented maxilla [1]. This was not found in our review.

Maxilla-first was also indicated for maxillary impaction [1], and mandible-first for posterior maxillary lowering and open bite treatment [19]. Turvey quantified a minimum of 5 millimeters of maxillary posterior lowering as an indication for mandible-first sequence [21]. This was found in our review where the results of maxillary vertical excess treatment, therefore by maxillary impaction, were more accurate when a maxilla-first was performed [13].

Table II. Data from included articles.

Author, year	Aim of the study	Material and methods (type of planning, operating sequence, methods for studying the accuracy of results)	Population (number, gender, age, surgical indication)	Surgery-related factors (operating time, revision of osteosynthesis, occurrence of complications)	Compliance of immediate skeletal and occlusal results	Length of follow-up and outcome
Beziat <i>et al.</i> , 2009 [11]	Asses the reliability of sagittal split osteotomy and Le Fort I osteotomy respectively, and to try to judge objectively the impact of their order for the final result of bimaxillary osteotomy	Articulator planning Mandible-first for all patients with condylar position using a T-shaped osteosynthesis plate and a centric relation splint Anteroposterior and transverse error quantification by measuring the offset between the target position and the position obtained using a first occlusal wax made intraoperatively after mandibular osteotomy and a second occlusal wax after maxillary osteotomy	<i>N</i> = 50 Female <i>N</i> = 31 Male <i>N</i> = 19 Age from 15 to 46 Skeletal class II <i>N</i> = 32 Skeletal class III <i>N</i> = 18	No information	After mandible osteotomy: – difference in anteroposterior positioning for 74% of cases with a mean backward or forward movement of 0.32mm (maximum 1mm) – difference in transverse positioning for 48% of cases with a mean error of 0.19mm (maximum 0.75mm) After maxillary osteotomy: – difference in anteroposterior positioning for 8% of cases with a mean error of 0.02mm (maximum 0.5mm) – no error in transverse positioning Authors concluded that beginning with the mandible allows correction of sagittal split mistakes with the Le Fort 1 osteotomy	No information
Ritto <i>et al.</i> , 2014 [4]	Comparison of maxillary repositioning according to the operative sequence in vertical and sagittal dimensions	Semi-adjustable articulator planning with positioning maxillary model using a facebow to create an intermediate splint and on cephalometric prediction Measurement of maxillary central incisor position on cephalometric planning and immediate postoperative cephalometry	<i>N</i> = 40 Female <i>N</i> = 23 Male <i>N</i> = 17 <i>Maxillar-first group:</i> <i>N</i> = 20 Female <i>N</i> = 9 Male <i>N</i> = 11 <i>Mandible-first group:</i> <i>N</i> = 20 Female <i>N</i> = 14 Male <i>N</i> = 6	No information	No statistically significant difference in vertical and sagittal dimensions on maxillary positioning	No information

Table II. (continued).

Author, year	Aim of the study	Material and methods (type of planning, operating sequence, methods for studying the accuracy of results)	Population (number, gender, age, surgical indication)	Surgery-related factors (operating time, revision of osteosynthesis, occurrence of complications)	Compliance of immediate skeletal and occlusal results	Length of follow-up and outcome
Liebrechts <i>et al.</i> , 2017 [12,14]	Assessment of the accuracy of jaws postoperative three-dimensional positioning in accordance with the virtually simulated position regarding to the operative sequence	Digital planning on CBCT performed 1 month prior to the surgery to design intermediate and final splints 4-year study: mandible-first group made up of patients operated between 2010 and 2012, and maxillary-first group included patients operated between 2012 and 2014 Comparison of jaw position between digital planning and postoperative CBCT at 1 week by superimposing bone surfaces and computing differences in translation and rotation of maxilla and mandible	<i>N</i> = 116 Female <i>N</i> = 80 Male <i>N</i> = 36 <i>Maxillar-first group:</i> <i>N</i> = 58 Female <i>N</i> = 43 Male <i>N</i> = 15 Mean age 28.6±11 years <i>Mandible-first group:</i> <i>N</i> = 58 Female <i>N</i> = 37 Male <i>N</i> = 21 Mean age 27.5±10.6 years	No information	Greater accuracy of outcome with maxillary-first sequence, especially in the anteroposterior dimension, as condyles are only manipulated during mandibular synthesis, whereas they are handled twice in mandible-first sequence	One year follow-up with the study of difference in positioning between postoperative CBCT at 1 week and CBCT at 1 year on 106 patients: comparable skeletal recurrence between the 2 groups
Salmen <i>et al.</i> , 2018 [13]	Evaluation of surgical position according to the surgical sequence to correct maxillary vertical excess	Articulator-based planning using a semi-adjustable articulator in centric relation (without specifying recording technique) for intermediate and final splints design Comparison of vertical and horizontal position on preoperative simulation and 30 days postoperative cephalometrics	<i>N</i> = 32 vertical maxillary excess <i>Maxillar-first group:</i> <i>N</i> = 16 Female <i>N</i> = 10 Male <i>N</i> = 6 Mean age 27 years <i>Mandible-first group:</i> <i>N</i> = 16 Female <i>N</i> = 9 Male <i>N</i> = 7 Mean age 28 years	No information	Adequate clinical accuracy of the 2 sequences with better precision in vertical position of the maxilla with maxilla-first sequence <i>Maxilla-first group:</i> better accuracy of A point and maxillary incisor vertical position more posterior pogonion position <i>Mandible-first group:</i> better accuracy of pogonion position lower position of posterior nasal spine and A point	

Table II. (continued).

Author, year	Aim of the study	Material and methods (type of planning, operating sequence, methods for studying the accuracy of results)	Population (number, gender, age, surgical indication)	Surgery-related factors (operating time, revision of osteosynthesis, occurrence of complications)	Compliance of immediate skeletal and occlusal results	Length of follow-up and outcome
Stokbro <i>et al.</i> , 2019 [15]	Explore whether the theoretical advantages of using the mandible-first procedure were supported by clinical data	Retrospective investigation on a cohort compiled from 3 published retrospective studies	<i>N</i> = 145 Female <i>N</i> = 99 Male <i>N</i> = 46 Mean age 28 years	No information	Overall surgical precision: maxilla-first sequence: position closer to planning mandible-first sequence: position more posterior than planned Accuracy of clockwise and counter-clockwise rotation of maxilla-mandibular complex: no statistically significant change between the 2 sequences, but : maxilla-first sequence increased in accuracy for clockwise rotation mandible-first sequence increased in accuracy during anti-clockwise rotation	No information
Borikanphanitphaisan <i>et al.</i> , 2021 [16]	Assessment of the accuracy of postoperative jaws positioning with the use of intermediate splints according to the operative sequence in all three dimensions	Digital planning on CBCT taken 1 month before the intervention in natural head position Determination of the surgical sequence based on the principle of avoiding mandibular opening at the intermediate stage: mandible-first if maxillary lowering and counter-clockwise rotation of the maxilla-mandibular complex Comparison of jaws position between digital planning and postoperative CBCT at 1 week by superimposing bone surfaces by an author who	<i>N</i> = 57 <i>Maxilla-first group</i> : <i>N</i> = 31 Female <i>N</i> = 20 Male <i>N</i> = 11 Mean age 24.6±5.9 years Class III <i>N</i> = 26 Class II <i>N</i> = 4 Asymmetry <i>N</i> = 1 <i>Mandible-first group</i> : <i>N</i> = 26 Female <i>N</i> = 17 Male <i>N</i> = 9 Mean age 26.4±7.4 years	No information	Overall accuracy: no statistically significant difference (<i>P</i> =0.084) Accuracy in vertical dimension: statistically significant difference (<i>P</i> =0.014) with mandible-first sequence more accurate than maxilla-first Accuracy in transverse and sagittal dimensions: no statistical difference Splint thickness: no effect of thickness on overall accuracy, only sagittal control of central incisors improved by splint thickness	No information

Table II. (continued).

Author, year	Aim of the study	Material and methods (type of planning, operating sequence, methods for studying the accuracy of results)	Population (number, gender, age, surgical indication)	Surgery-related factors (operating time, revision of osteosynthesis, occurrence of complications)	Compliance of immediate skeletal and occlusal results	Length of follow-up and outcome
		did not know the sequencing group using linear and angular measurements based on craniofacial landmarks to highlight discrepancies in translational and rotational movements				
Hamdy and Elfarawawi, 2021 [17]	Stability of surgical results evaluation according to surgical sequence for Class III treatment	Digital planning on CBCT to design the splints Registration of centric relation with occlusal was, occlusion scanning with optical impression integrated into the planning software with the CBCT (no precision on possible condyle repositioning) Software randomization, blind patient Comparison of jaw position at 1 week and 6 months postoperatively by comparing bone and skin cephalometric points	<i>N</i> = 24 class III Age between 18 and 26 years <i>Maxilla-first group:</i> <i>N</i> = 12 Female <i>N</i> = 7 Male <i>N</i> = 5 <i>Mandible-first group:</i> <i>N</i> = 12 Female <i>N</i> = 4 Male <i>N</i> = 8	No information	Bone points: statistically significant differences between the two groups Soft tissues points: no statistically significant difference between the two groups except for soft tissue inclination (nose-lip relationship) Patient satisfaction similar between the 2 groups No difference in results stability according to the operative sequence	No information

Table III. Assessment of risk of bias using the ROBINS-I Tool applied to cohort studies.

	Risk of bias judgement							Overall risk of bias
	Bias due to confounding	Bias in selection of participants into the study	Bias in classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias of measurement of outcomes	Bias in selection of the reported results	
Beziat et al., 2009 [13]	M	L	S	M	L	L	L	M
Ritto et al., 2014 [4]	M	L	L	M	L	M	L	M
Liebrechts et al., 2017 [15]	L	L	L	L	L	L	L	L
Salmen et al., 2018 [11]	M	L	L	L	L	M	L	M
Liebrechts et al., 2019 [17]	L	L	L	L	L	L	L	L
Stokbro et al., 2019 [12]	C	M	S	M	M	S	S	S
Borikanphanitphaisan et al., 2021 [14]	L	L	S	S	L	L	L	M
L: low risk M: moderate risk S: serious risk C: critical risk N: no information								

Table IV. Assessment of risk of bias using the RoB 2 Tool applied to randomized clinical trial.

	Risk of bias judgement					Overall risk of bias
	Bias arising from the randomization process	Bias due to deviations from intended interventions	Bias due to missing data	Bias of measurement of outcomes	Bias in selection of the reported results	
Hamdy and Elfaramawi, 2021 [16]	L	L	L	L	L	L
L: low risk SC: some concerns H: high risk						

Several authors have suggested that mandible-first should be performed in case of significant mandibular advancement [19,20], whereas maxilla-first was indicated for small maxilla-mandibular advancement movements [1]. The amount of movement was not precisely quantified. We didn't find this in our review, where the surgical sequence either to have no influence on the treatment of anteroposterior dimension [4,16], or to be more precise with a maxilla-first sequence [12].

Perez and Ellis described specific cases in which it would be preferable to perform a mandible-first such as concomitant temporomandibular joint (TMJ) surgery [2,19]. Turvey expanded on the concept of complementary TMJ surgery, mentioning the example of condyles replaced by rib grafts [21]. No article in our review mentioned concomitant TMJ surgery, which was often an exclusion criterion in many studies.

Osteosynthesis

Before the emergence of plates and screws, bone fixation was achieved using wires and skeletal fixtures. Maxilla was operated first, stabilized by steel wires, and then the mandible, stabilized by intermaxillary blocking [21]. Lindorf and Steinhäuser described a modified sequence for orthognathic bimaxillary surgery in which mandible had to be operated on first because a stable reference, the maxilla, was needed to reproduce the planned movements accurately [5]. Buckley

et al. highlighted the disadvantage of starting with maxilla due to the instability of the previously operated maxilla which could be displaced during mandibular osteosynthesis. More rigid fixation rather than wire osteosynthesis was mandatory to achieve a mandible-first surgery [22]. Cottrell and Wolford proposed that mandible-first sequence should be performed in cases where maxillary surfaces are thin, leading osteosynthesis difficult. Conditions required for mandible-first sequence were correct placement of the condyles in mandibular fossae and rigid osteosynthesis [20].

None of the articles in our review studied osteosynthesis as a factor that could determine the operative sequence, either in osteosynthesis method or as a factor of inaccuracy requiring revision of the osteosynthesis intraoperatively and/or post-operatively.

Operating time

To our knowledge, none of the articles in our review nor in the literature have studied the surgery duration as a factor in surgical sequence choice.

Intra- and/or post-operative complications

To our knowledge, none of the articles in our review nor in the literature have studied the occurrence of complications as factor in the decision on the operative sequence.

Table V. Overview of decision criteria for surgical sequence in bimaxillary surgery.

	Maxilla-first sequence	Mandible-first sequence
Centric relation registration	Easy [18]	Easy and difficult [18]
Intermediate splint		No consensus [2,16,19]
Planification type		No consensus [18,20]
Maxillo-mandibular complex rotation	Clockwise rotation [1–3,15]	Counter-clockwise rotation [1–3,15,19]
Segmentation of the maxilla	Non segmented maxilla [1]	Segmented maxilla [19,20]
Maxillary vertical movement	Impaction [1,13]	Lowering more than 5 millimeters [19,21] Open bite treatment [20]
Maxillo-mandibular complex advancement	Small movement [1]	Large movement [18,20]
Simultaneous temporomandibular joint surgery	At a different operating time [2,19,21]	Possible in the same surgery [2,19,21]
Osteosynthesis	Steel wire or plates and screws [21]	Plates and screws only [22]
Temporomandibular disorder		Not studied
Accuracy of the results		No consensus [1–6,11,12,14,16–22]
Results stability		Recurrence independent of surgical sequence [14]

Postoperative relapse

The sequence of surgical procedures in orthognathic surgery did not seem to influence the risk of postoperative skeletal relapse. Studies indicated that both maxilla-first and mandible-first approaches result in similar postoperative skeletal stability, with mean sagittal, vertical and transverse relapse being less than 1.8mm, showing no significant differences between the two sequences [14].

Strengths and limitations

This systematic review was carried out according to PRISMA, which fulfils the criteria for repeatability and reduces the risk of the conclusions being affected by arbitrariness or chance. The aim of this systematic review was to provide scientific evidence regarding the surgical sequence for bimaxillary surgery. Eight studies fulfilled our inclusion criteria and were included. All articles included had a control group, which enabled the results of the two surgical sequences to be compared by the same authors, thus avoiding bias.

However, limitations in this study should be highlighted. Studies included were few in number and of medium level of evidence (large majority of retrospective cohort studies) and moderate risk of bias for half of them. Only two studies reported results at six months and one year after the bimaxillary surgery. This lack of data made difficult to formally conclude on the controversy regarding the best surgical sequence in orthognathic bimaxillary surgery. Data concerning intra and/or postoperative complications, especially temporomandibular disorders, were not found. The articles did not describe precisely the recording methods for centric relation and condyles position, which could explain the inaccuracies found. A meta-analysis was not

conducted due to the heterogeneity of studies, the small number of studies included and the differences in outcomes measurement across studies.

Conclusion

Currently, the decision on the operative sequence in bimaxillary surgery is based on precise preoperative planning and depends on the surgeon's experience and preference. Indications for each surgical sequence seem to be identifiable according to specific clinical conditions, as summarized in this article. For this reason, each surgery must be planned beforehand in order to determine the best operative sequence for each patient. Further studies with a higher level of evidence are needed to determine the surgical sequence that provides the best accuracy and stability of occlusal and skeletal results in long term, depending on the clinical context. Studies to assess the impact of the surgical sequence on the appearance or improvement of temporomandibular dysfunction would also be of interest.

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Conflicts of interest

All authors have no conflicts of interest to declare.

Data availability statement

All data are available from the corresponding author upon reasonable request.

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