

Indications for Orthognathic Surgery - A Review

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Abstract

Background: Orthognathic surgery is a relative common procedure for correcting skeletal malocclusions and deformities. The indications for orthognathic interventions remain, however, controversial. Objective: To conduct a systematic review of studies regarding the indications, logistics, and outcome related to orthognathic surgery. Material and methods: An electronic online search was conducted using PubMed. Key words included “Orthognathic,” “Outcome,” and “Prognosis.” Additional studies were identified through reference lists of the identified studies. Only studies published from 2000 until November 2015 were included. Results: The search identified 24 publications. All studies evaluated the indications for orthognathic surgery from the patients’ point of view. The included studies showed large variation in study design. No meta-analysis could be performed regarding the indications or outcome. The two most commonly cited indications for orthognathic surgery are functional dental problems and aesthetics considerations. Conclusion: Health is a multidimensional, complex concept that is difficult to evaluate. Every patient must be assessed individually in relation to the indications for orthognathic surgery and their general health. Although, future, more objective guidelines for the indications for orthognathic surgery could be considered, the individual estimates remain the most important parameters in current evaluation.

Key Words: Orthognathic surgery, oral Health, Oral and Maxillofacial Surgery

Introduction

Orthognathic surgery (OS) is a surgical intervention that alters relationships of the jaws and dental arches. The treatment involves a combination of orthodontics and maxillofacial surgery. It is used to correct dentofacial deformities that cannot be treated with acceptable results by conventional orthodontics (*Figure 1*). The first description of a surgical intervention to correct a malocclusion was by Hüllihen in 1849 [1]. The most frequently used surgical procedures for correcting the relationship of the jaws are Le Fort I osteotomy and sagittal ramus split osteotomy. Also often used are vertical ramus osteotomy, inverted L osteotomy, and variations and combinations of the above. Le Fort I was already described in 1867 and in 1953, Obwegeser introduced the sagittal split osteotomy [1].

planning of orthognathic procedures. Three-dimensional planning seems to be the new gold standard, and virtual planning is well described in the literature [2–5].

The motives for seeking OS are many and various, and the decision of performing a surgical intervention depends on several aspects, e.g. dental or skeletal deviations, growth, psychological components, and functional status. The impact on function and closely related quality of life parameters of having a dentofacial deformity may be considerable. Already in the 1970s, it was claimed that the specific criteria for OS were highly subjective[6]. A committee in the United States was established to make an objective definition of when an orthodontic condition was seriously handicapping and indicated a combined surgical-orthodontic intervention. The committee agreed on the following: “A seriously handicapping orthodontic condition is a dentofacial abnormality that severely compromises a person’s physical or emotional health” [7]. This definition can be difficult to assess objectively. Today, there is still a lack of consensus regarding the indications for orthognathic treatment procedures [8–10]. The primary indication is when the deviation in skeletal jaw relations is severe enough to be a functional or aesthetic, psychosocial problem.

The incidence of OS procedures is increasing [11]. Worldwide, no database on the number of treatment procedures exists. In 2015, around 1,000 orthognathic treatment procedures were performed in Denmark [12]. Different health care systems exist demographical, which has an influence on the various prevalence, motives, indications, and procedures for OS. In the Danish national healthcare system, patients can be entitled to orthognathic treatment procedures under specific circumstances. According to Danish Healthcare Legislation, the indications for OS must be functional – or psychosocial problems [13]. In addition, most health care insurance programmes in the United States cover OS when the reasons for the procedure are functional problems.

OS aims to correct dentofacial deformities, including:

- Malocclusions owing to skeletal problems, including severe Class II or Class III problems, anterior open bites, increased overbites, and facial asymmetries
- Temporomandibular joint disorders (TMD)
- Obstructive sleep apnoea/hypopnoea syndrome (OSAHS)
- Cleft lip and palate
- Hemi-facial microsomia
- Post-traumatic jaw deformities and malocclusions

Figure 1. Aims to correct dentofacial deformities.

Since then, progress in OS has taken place. Various aspects of OS have been investigated, and this has led to huge progress regarding efficient and predictable outcomes following surgical intervention. The most recent advances are three-dimensional imaging and computer-assisted surgical

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Generally, high satisfaction and significant functional improvements following OS are described in the literature [14]. Furthermore, various benefits including improvements in facial aesthetics, psychosocial well-being, physiological health, regress of pain, etc., are reported [8,15]. In studies about the patients' subjective motives and satisfaction following OS, improvement in facial aesthetics is described as one of the main indications for OS. Regarding the guidelines for economically covered orthognathic treatments, the subjective expression of aesthetics as an indication can be contentious. In addition, the various health-related, functional, and aesthetic indications for OS are controversial in relation to patients, professionals, insurance programmes, and different health care systems.

The purpose of this review is to investigate the indications and outcomes following OS as reported in the literature. OS is a complex process that changes the function of the dentofacial structures including mastication, speech, respiration, and swallowing. With focus on the indications and benefits, the importance of the orthognathic treatment procedures in the healthcare system can be evaluated.

Methods

A web-based search was conducted using the National Center for Biotechnology Information (NCBI) to search Medline (PubMed). Only publications in the period from January 2000 to November 2015 were included. The following search syntax was used: "Orthognathic", "Outcome", and "Prognosis". Inclusion criteria were following 1) language, English; and 2) a sample size of 20 patients or more. Exclusion criteria were 1) case reports with less than 20 patients; 2) surgery due to trauma, cancer, syndromes, or cleft lip and palate; 3) only orthodontic treatment (non-surgical); 4) follow-up period of 6 or fewer months after surgical intervention. In addition, a thorough bibliographic hand search identified further publications. The hand search included

retrieving important publications mentioned in the reference lists of identified articles. The screening was carried out according to the inclusion and exclusion criteria. Headings were screened for inclusion or exclusion criteria. Abstracts for included headlines were screened for inclusion or exclusion criteria. Finally, if the abstract was included, the full article was reviewed.

The data retrieved from the selected studies included author, country, year of publication, sample size, study design, methods/measurements, and maximum follow-up period. The purpose of the data collection was to provide a basis for a meta-analysis.

Results

The web-based search strategy yielded 571 articles (*Table 1*). Fifty-five titles and abstracts were recognized as potentially appropriate. The full articles were then retrieved, and 16 publications fulfilled the selection criteria [8,16-30]. The bibliographic hand search identified 13 publications as appropriate (*Figure 2*) [9,31-37]. *Tables 2 and 3* show the data from the included studies. A meta-analysis of the indications for and outcomes of OS could not be performed because studies used different designs. Nine of the studies investigated the patients' motives for undergoing OS. The indications/motives were measured by different questionnaires (graduated and non-graduated) and with different options for motivation (*Table 4*). Nineteen studies investigated the outcome following OS. The follow-up period and the method for investigation of the outcome varied with regard to questionnaires, visual analogue scales, and clinical methods. Because the different study designs and measurements set limits for comparison, the data from the studies were used to describe the visitation methods, indications, and motives for OS, and the outcomes following OS. Furthermore, we cite key contributions from important previous publications that have addressed visitation methods and complications.

Table 1. Data for web-based search using PubMed.

| Search | MeSH Term | Time limit (publication date) | Results | Included |
|--------|--------------------------------|-------------------------------|---------|----------|
| #1 | Orthognathic | All | 4239 | |
| #2 | Orthognathic | 2000-present | 3056 | |
| #3 | Orthognathic Outcome | All | 918 | |
| #4 | Orthognathic Outcome | 2000-present | 784 | |
| #5 | Orthognathic Prognosis | All | 677 | |
| #6 | Orthognathic Prognosis | 2000-present | 593 | |
| #7 | Orthognathic Outcome Prognosis | All | 637 | |
| #8 | Orthognathic Outcome Prognosis | 2000-present | 571 | 16 |
| Total: | | | | 16 |

Table 2. Included studies from web-based search.

| Author | Country | Year of publication | Study design | Study group (W/M) | Aim of study: Methods/measurements | Observation period (time after OS) |
|--------|---------|---------------------|--------------|-------------------|------------------------------------|------------------------------------|
|--------|---------|---------------------|--------------|-------------------|------------------------------------|------------------------------------|

| | | | | | | Questionnaire | Clinical examination | |
|------------------------------|----------------|------|------------------------------|--|--|---------------|-------------------------------|------------------|
| Panula et al.[1] | Finland | 2000 | Prospective Case-control | 60 (49W/11M) (Control group: 20) | Outcome. Effect on TMJ dysfunction | X | X | 20-44 months |
| Throckmorton et al.[2] | United States | 2001 | Prospective | 104 (72W/32M) | Outcome. Effect on bite force | | Bite force transducer. X-rays | 36 months |
| Kobayashi et al.[3] | Japan | 2001 | Prospective Case-control | 27 (20W/7M) Control group: 40 (16W/24M) | Outcome. Effect on masticatory efficiency | | X | 24 months |
| Harada et al.[4] | Japan | 2003 | Prospective | 24 (11W/13M) | Outcome. Effect on bite force | | X | 12 months |
| Lazaridou-Terzoudi et al.[5] | Denmark | 2003 | Case-control | 117 (64W/46M) (Control group: 131) | Outcome. Effect on function, aesthetic, psychosocial problems, etc. | X | | Not mentioned |
| Nakata et al.[6] | Japan | 2007 | Prospective Case-control | 37 (24W/12M) (Control group: 30) | Outcome. Effect on bite force, muscle activity | | X | 31 months |
| Pahkala et al.[7] | Finland | 2007 | Prospective | 82 (53W/29M) | Outcome. Effect on TMJ dysfunction, aesthetic, psychosocial well-being | X | X | Mean 21.6 months |
| Lee et al.[8] | Hong Kong | 2008 | Prospective | 36 (25W/11M) | Outcome. Quality of life | X | | 6 months |
| Espeland et al.[9] | Norway | 2007 | Retrospective | 516 (281W/235M) | Outcome and motivation. Effect on appearance, function, oral health | X | X | 18 months |
| Nicodemo et al. [10] | Brazil | 2007 | Prospective | 29 (?) | Outcome. Effect on function, psychosocial well-being, aesthetics | X | X | 6 months |
| Øland et al.[11] | Denmark | 2010 | Prospective | 92 (57W/35M) | Outcome and motivation. Effect on function and psychosocial well-being | X | | 36 months |
| Øland et al.[12] | Denmark | 2010 | Prospective | 118 (67W/51M) | Outcome. Effect on function and psychosocial well-being | X | X | 12 months |
| Dujoncquoy et al. [13] | Germany | 2010 | Retrospective | 57 (35W/22M) | Outcome. Effect on TMJ dysfunction | X | | 6-30 months |
| Ponduri et al.[14] | United Kingdom | 2010 | Retrospective | 23 (?) | Outcome. Effect on function, psychosocial well-being, aesthetics | X | | Not mentioned |
| Øland et al.[15] | Denmark | 2011 | Prospective | 118 (67W/51M) | Outcome. Effect on function | X | X | 12-36 months |
| Al-Ahmad et al. [16] | Jordan | 2014 | Retrospective (case-control) | 39 (27W/13M) | Outcome. Functional, psychosocial, aesthetics | X | X | 6-21 months |

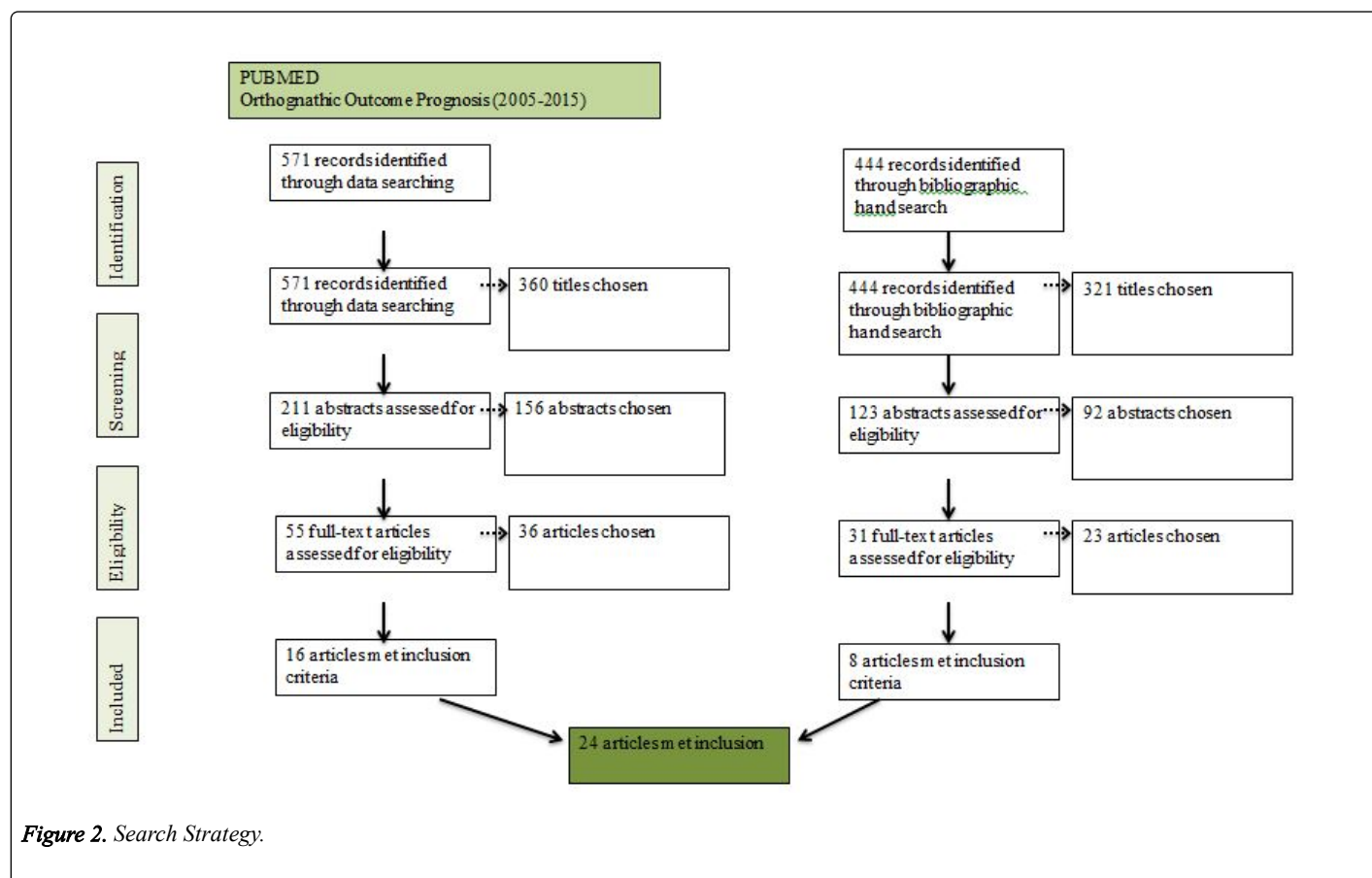
Table 3. Included studies from bibliographic hand search.

| Author | Country | Year of publication | Study design | Study group (W/M) | Methods/measurements | | | Maximum observation period (time after OS) |
|-----------------------------|---------------|---------------------|-----------------------------|--|------------------------------------|----------------------|----------------------|--|
| | | | | | Aim of study | Questionnaire | Clinical examination | |
| Peacock et al. [17] | United States | 2014 | Retrospective | 911 (476W/435M) | Motivation. Functional, aesthetic | X | | 24 months |
| Hernandez-Alfaro et al.[18] | Spain | 2014 | Retrospective | 362 (212W/150M) | Motivation | | X | Not mentioned |
| Hernandez-Alfaro et al.[19] | Spain | 2014 | Prospective | 45 (27W/18M) | Outcome and motivation | ? (VAS satisfaction) | X | 12 months |
| Proothi et al. [20] | United States | 2010 | Retrospective | 501 (285W/216M) | Motivation (main indication) | X | | Not mentioned |
| Modig et al.[21] | Sweden | 2005 | Prospective | 32 (16W/16M) | Motivation (main indication) | X | | Not mentioned |
| Hågensli et al. [22] | Norway | 2013 | Retrospective Case-control? | 396 (192W/204M) incl. control group of 160 | Motivation | X | | Not mentioned |
| Wolford et al. [23] | United States | 2003 | Retrospective | 25 (23W/2M) | Outcome. Effect on TMJ dysfunction | X | X | 81 months |
| Larsen et al. | Denmark | 2015 | Retrospective | 105 (93W/12M) | Outcome and motivation | X | | Not mentioned (> 60 months) |

Table 4. Indications for orthognathic treatment.

| Author | Study group | One option for indication | Functional | | | | | Appearance | | | OSAHS |
|------------------------|-----------------|---------------------------|------------------------------------|-----------------------------------|-------------|--------------|------|------------------------------------|------------------------------------|-----------|-------|
| | | | Chewing and biting | Speech | Degustation | Malocclusion | Pain | Dental | Facial | Aesthetic | |
| Espeland et al. | 516 (281W/235M) | | 80% (important and very important) | | | | | 80% (important and very important) | 70% (important and very important) | | |
| Øland et al. | 92 (57W/35M) | | | | | | | | | | |
| Peacock et al. | 911 (476W/435M) | | 67% | | | | | | | 33% | |
| Hernandez-Alfari et al | 362(212W/150M) | | 41% | | | | | | | 57% | 2% |
| Hernandez-Alfari et al | 45 (27W/18M) | | | | | 7% | | | | 82% | 11% |
| Proothi et al. | 501 (285W/216M) | X | 36% | | | | | | | 15% | |
| Modig et al. | 32 (16W/16M) | X | 55% | 13% | 2% | | | | | 30% | |
| Hågensli et al. | 396 (192W/204M) | | 82% (very and somewhat important) | 33% (very and somewhat important) | | | | 88% (very and somewhat important) | 70% (very and somewhat important) | | |

| | | | | | | | | | | |
|---------------|---------------|--|--|--|-----|-----|--|--|-----|--|
| Larsen et al. | 105 (93W/12M) | | | | 14% | 72% | | | 54% | |
|---------------|---------------|--|--|--|-----|-----|--|--|-----|--|



Consultation/visitation and procedures

Patients with significant dentofacial deformities causing functional or psychosocial problems should be referred to maxillofacial surgeons for assessment of growth anomalies. In Denmark, health legislation has established rules for visitation, so every individual will have the same opportunity to go through an orthodontic or combined orthodontic and surgical treatment if it is required. The patients are individually assessed according to their dentofacial deformity and health [13,38]. No guidelines for when, where, and how the assessment should be achieved is described in the literature. In Denmark, guidelines from the Danish health legislation are used to include patients.

Treatment plans are made according to the individual patient and consist of a combined orthodontic and surgical adjustment of the deformity and malocclusion. Treatment includes three stages:

- Orthodontic treatment before surgery: Involves a correction of abnormal tooth position.
- Orthognathic surgery: Involves a correction of the jaws.
- Orthodontic treatment after surgery: Involves a final adjustment of the teeth.

The total orthognathic treatment procedure takes typically 2-3 years [11,38].

Indications

The indication for orthognathic treatment is to prevent or to treat dentofacial deformities that involve foreseeable or existing risks for physical and/or psychosocial problems. No strict, objective guidelines regarding the indications for OS were found in the literature with the search strategy used. Furthermore, because of variations in health care systems and visitation methods/criteria differences exist in the indication for OS.

Table 4 shows the data from studies regarding the indications for OS. Thirty-six to sixty-seven percent of the patients in the studies indicated functional problems as the indication for OS. The functional problems were the main indication in 36-55% of the patients [8,9,39]. Different questionnaires were used to investigate the reasons for OS, and in spite of this, the explanation for the functional problems varied. In some studies the functional problems were divided into problems with speech, swallowing, chewing, etc., whereas other studies included only one category of functional problems [34]. As mentioned previously, the heterogeneity of the studies represented limitations for the comparisons. Overall, the studies showed that alleviation of function was a main indication for OS.

Fifteen to eighty-two per cent of the patients replied that aesthetic considerations were their indication for OS. In most of the studies, the patients were able to name more than one indication. In two studies, the patients had to choose their primary indication for OS, which most frequently was an

alleviation of functional problems. Fifteen to thirty percent of the patients replied that aesthetic considerations were the primary indication.

One study included psychosocial problems as the indication for OS. Functional and aesthetic problems were the other indications. Ten per cent of the patients indicated psychosocial problems as the reason, whereas 52% and 31% named aesthetics and functional problem as the indication [40].

Outcome

Studies regarding the outcome following OS are seen in Table X. Generally, the studies reported satisfaction following OS. Three studies investigated the effect of OS on bite force [17,19,21]. All of the studies reported an improvement in maximum bite force following OS. Throckmorton et al. investigated the relationship between the skeletal morphology and bite force. They did not show a relationship and claimed that the increased bite force probably could be explained by an increase in occlusal contact area [17].

Panula et al. investigated in a prospective, clinical study the effect on temporomandibular joint (TMJ) dysfunction. The biggest improvement following OS was in the frequency of headache. Furthermore, significant reduction in signs and symptoms of TMJ dysfunction were seen [16]. Dujoncqouy et al. demonstrated some improvement in TMJ disorders in a retrospective study [28].

All studies regarding aesthetics were based on questionnaires. The studies showed an improvement in facial aesthetics following OS. Fifteen to eighty-two per cent of the patients stated that they had experienced an improvement.

Side effects

There is a risk of complications and side effects with every surgical intervention. The literature shows a great variety of severe complications following OS, and the frequency of complications is very low. The most frequently mentioned complications are infections, relapse, neurosensory disturbances, condylar resorption, TMJ problems, injured teeth, and unsatisfied occlusal outcome [24,41-44]. Thus, it is crucial that patients are well informed and aware of the risk of subsequent side effects before approving the orthognathic treatment. Studies report that the level of satisfaction depends on the expected effects. Dissatisfaction is related to unexpected side effects [40,44].

Discussion

Epidemiology

Around 2-3% of the population in the United States has deformities that require OS [11]. Approximately 1% of the population in Denmark is claimed to have dentofacial deformities that require OS. The exact incidence of dentofacial deformities requiring OS is difficult to estimate. The estimate depends on the definition of the deformities, which varies according to study design and relies on a professional's (subjective) evaluation. Therefore, it is not possible to give an exact incidence of the dentofacial deformities. Several, epidemiologic studies have attempted

tried to determine the incidence. Due to heterogeneity in study design, it is not possible to compare the data. Furthermore, epidemiologic studies show that the distribution of the incidence of dentofacial deformities varies according to different ethnicities [45,46].

Proffit et al. have described the incidence of OS procedures performed in the United States [11]. No studies or data on the incidence of OS procedures performed in Europe is found in the literature. In Denmark, the incidence of orthognathic treatment procedure is increasing. Thus, recent numbers from the Danish National Health board, indicate, that approximately 1,000 OS procedures were performed in 2015 [12]. The literature is controversial regarding changes in the incidence. Sullivan et al. showed a reduction in the number of orthognathic treatment procedures performed from 1991 to 2007 [47]. Other researchers also report the same reduction in the number of procedures [48]. These studies investigated only the OS procedures performed in the United States. Furthermore, the data from Sullivan et al. included only OS performed in the public sector. No data from the private sector were included [47]. Kelly et al. investigated the incidence of OS among respondents with their primary occupation in the private sector and showed an increase in OS [49]. The reduction in OS in the study by Sullivan et al. can perhaps be explained by a shift in the sectors: more orthognathic treatment procedures are being performed in the private sector than previously. Another study used a questionnaire to estimate the number of OS procedures performed in Ohio. The respondent's rate was 39%, and 90% of the respondents reported a decrease in the number of OS performed over the last 5 years. The data were not validated and referred only to the situation in Ohio. Furthermore, no explanation for the low respondents rate was mentioned. Perhaps, the non-respondents were busy performing OS, whereas the respondents with a decrease in number of OS had time to fill out the questionnaire [48]. In conclusion, these study results cannot be generalized. A database of OS performed in both the private and public sectors and worldwide is essential for the valuation of the epidemiology of dentofacial deformities and in orthognathic treatment procedures.

Consultation/visitation and procedures

Assessment of the potential necessity for OS is complex. All patients are seen individually, and the number of visits and the further treatment are based on the professionals' knowledge and experience. This can result in variety of treatment offers. To minimize the variation in treatment offers in Denmark, professionals go through an orthodontic calibration exercise [13]. Danish health legislation has proscribed visitation criteria to be used as a guideline in the individual visitation of the patient [13]. Other health care systems and insurance systems in other countries have elaborated similar guidelines [38]. The guidelines' purpose is to ensure that every patient is offered the same opportunity to receive orthognathic intervention if it is indicated.

No recommendations regarding the appropriate time for surgical-orthodontic assessment are found in the literature. Frequently, general dental practitioners refer the patients to orthodontists or maxillofacial surgeons for assessment [50]. In Denmark, the visitation methods vary regionally. Danish

health legislation is not precise and adequate regarding the timing of treatment and the visitation/referral method, which results in different interpretations. Orthodontic visitation is normally undertaken when the patients are in the children's dental care programme. In some cases, orthodontic treatment can use normal growth to alter the relationship of the jaws. In such cases, the orthodontic assessment and treatment plan should be made before the growth period ends, which implies the importance of early visitation. In other cases, the dentofacial deformity is severe, and surgical intervention to correct the relationship is the most appropriate treatment.

Early orthodontic assessment combined with a treatment plan can sometimes result in less need of combined surgical-orthodontic intervention. The functional and psychosocial problems can be expressed later, and the treatment can for some patients (and parents) seem unmanageable. The patient's perception of need for an orthognathic intervention may change over time. It is important that the patients get appropriate information about prognosis and later complications if OS is not performed. Instead of no treatment, some patients are interested in orthodontic camouflage. Orthodontic treatment/camouflage in patients in whom there is the potential for combined surgical-orthodontic treatment will result in a less successful outcome. The less successful/poor outcome has been described in patients with asymmetry, a poor soft tissue profile, increased vertical proportion, and anterior open bite [51]. These are important facts in treatment planning and patient information.

In addition, some patients seek orthognathic correction after previous orthodontic treatment/camouflage. Some of the negative effects associated with repeat orthodontic treatment are prolonged compliance and treatment time, undesirable extractions, increased complexity of surgical management, increased risk of dental diseases (including caries, root resorption, and periodontal disease), and extra cost to health care systems, insurance companies, and the patients [50]. Because of these risk of these negative effects, it is important that potential orthognathic patients are identified early, so that orthodontic treatment is not performed, and patients are given the appropriate surgical-orthodontic treatment is given at the optimal time. Appropriate information is crucial in deciding the surgical intervention and/or single orthodontic treatment/camouflage.

Recently, there has been an increase in older patients seeking OS [45,46]. Greater satisfaction, low morbidity, and positive outcome in function and health can explain the increased incidence of OS undertaken in older patients. Furthermore, inadequate visitation or solitary orthodontic treatment in cases in which combined orthodontic and surgical treatment was indicated can have resulted in the previously mentioned unsatisfied outcomes. Studies show that motives to seek treatment vary significantly with age. Older patients are more likely to seek OS for functional reasons, whereas younger patients more often mention aesthetics as an indication [31,52]. Still, there is now more focus on aesthetics among the older population than previously. In spite of the increased incidence, the satisfaction in older patients is less than in younger patients [52–54]. Studies show that the risk for somatosensory changes following OS is higher among older patients than it is in younger patients [55]. Moreover,

Peacock et al. showed that older patients have longer hospital stays compared with younger patients [31].

In spite of the increase in the incidence of OS among older patients, it is important to evaluate the methods and procedures for orthognathic visitation. The increase can perhaps be explained by neglecting to go through with patients the treatment option during visitation or inadequate information about the benefits and negatives with and without orthognathic treatment. Performing the orthognathic intervention early can decrease the risk for somatosensory changes and result in greater satisfaction. Furthermore, the patients' quality of life with a malocclusion or deformity can deteriorate if treatment is delayed.

Indications and outcomes in relation to oral function

The two main indications for OS are functional or psychosocial problems [9,27,39,56,57]. In this review nine studies were retrieved regarding the indications for OS from the patients' point of views. Studies of the indications from professionals' points of view were not found.

The literature search found functional problem to be the indication in 7-82% of the patients. Oral function is difficult to measure objectively, which presents some limits in evaluating the outcome and comparing different studies.

Oral function is frequently assessed using quality of life measures. Other functional treatment guidelines are, among others, bite force, centric occlusion, and establishing stable normal occlusion with consistent centric relation of the TMJ [58]. A Danish prospective study showed significant improvement in oral function following OS. The prevalence of patients reporting severe symptoms related to oral function fell from 64% before OS to 20% after OS. Furthermore, changes in the clinical recognized dysfunction showed reduction following treatment [27].

The biting force is frequently used to evaluate masticatory efficiency. Picinato-Pirola et al. showed a significantly greater masticatory efficiency in patients without malocclusions compared to patients with class II or III malocclusion [59]. Other studies present similar results [60-63]. Some of the studies show that OS can improve function to normal levels [60,62]. Although, a review reported that the positive effect on bite force took 5 years to be achieved [64].

One study showed that 33% patient mentioned difficulties in speech and 15% of difficulties in swallowing [9]. Hassan et al. reviewed the literature for data of OS's effect on speech. They did not find any data that showed that OS corrected speech and swallowing problems [65]. Future investigation of orthognathic surgical intervention on speech and swallowing would be useful.

The effect of OS in TMJ dysfunction has also been investigated. Occlusal disharmony can lead to abnormal muscle activity, which can cause TMJ dysfunction. Dujoncquoy et al. demonstrated that orthognathic patients had a high prevalence of TMJ dysfunction. Eighty percent of the study group noted an improvement following OS [28]. Other studies show similar and significant improvement in TMJ dysfunction following OS [16,36,66], which might be

explained by the equilibrating of the occlusion with the combined orthodontic and orthognathic surgery.

All studies confirmed that orthognathic patients had compromised oral function prior to OS and OS could significantly improve it. No studies evaluated specific functional problems.

Indications and outcome in relation to quality of life (including aesthetics and psychosocial problems)

Health is a difficult parameter to quantify, but should be considered in any patient. Social well-being is an essential factor in the World Health Organization (WHO) [67]. The well-being can be assessed by measuring the quality of life, which is defined as: “Individuals’ perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns” [67]. Quality of life has become a relatively common outcome measure in medical studies and similar studies in maxillofacial surgery have been done and are ongoing [8,34,68-73]. The quality of life before, under, and after OS is an essential parameter to investigate in relation to the indications and outcomes for OS.

Quality of life is a multidimensional concept that includes subjectively perceived physical, emotional, and social function [67]. Various oral health questionnaires (both validated and invalidated) have been implemented regarding the different aspects of quality of life [8,68,74,75]. Evidence shows that orthognathic patients have a poorer quality of life before OS, and a psychosocial improvement is seen following orthognathic interventions [8,68-72]. According to a review by Hunt et al., the psychosocial benefits gained by orthognathic patients are better social functioning, social adjustment, self-confidence, self-concept, body image, emotional stability, self-esteem, attractiveness, positive life changes, and reduced anxiety [76]. Facial appearance has an influence of these benefits and is an important parameter in quality of life. Today’s culture makes demands on aesthetics especially with regard to communication via social media.

Many studies, which have primarily defined OS as a cosmetic intervention, have investigated improvement in facial appearance. In addition, some patients indicate aesthetics as a reason for OS. This present review found that 15-82% of the patients had aesthetic concerns as indication. It is essential to notice that appearance has an important psychological aspect. Beauty is difficult to measure and is subjective, but it is easier to use aesthetics as an indication than it is to use other psychological factors [37]. The face is a physical object that you can see and touch. Changes in facial appearance are seen following OS, which can explain appearance as indication for OS in relation to the quality of life. A subjective improvement in facial aesthetics is often described in the literature. Larsen et al. found aesthetics to be the indication in 54% of the patients and a subjective satisfaction with aesthetic aspects following OS in 84% [37]. An objective method for evaluating the facial aesthetic can be an essential tool in estimating the facial appearance as a factor in a patient’s health/quality of life. Different guidelines, norms, and standards have been proposed to describe the

ideal, aesthetic proportions in the face, e.g., the golden proportion, average values, etc. [77–81]. Because of various study designs that include different landmarks, ethnicity, ages, and sexes, the evidence for “ideal” ratios and angles is sparse. In 1982, it was claimed that an analysis of a beautiful face should be approached on the basis of golden proportions [82]. The so-called Golden Decagon Mask is constructed of a composite of pentagons with sizes in relation to golden proportions [79]. The use of golden proportion as an estimate for beauty is very controversial. Aesthetics is still being evaluated from a subjective point of view. Future investigation to define objective method for estimating beauty is needed.

The results following OS are important to evaluate and register in relation to describing its benefits and indications. The literature shows that the actual result/outcome following OS can take a long time to be achieved [64,69,76]. Magalhães et al. reported that it took up to 5 years to achieve a positive effect on bite force following OS [64]. In addition, Hunt et al. did not find any studies with a high level of evidence in the literature that evaluated the long-term psychosocial benefits of OS [76]. Future, well-controlled, longitudinal studies about the outcome following OS with regard to oral function, self-concepts, and social interactions should be done. Furthermore, there is a lack of studies that include control subjects without dentofacial deformities. OS is frequently performed in relatively young patients where many psychosocial changes are taking place. To verify the concrete benefits of an orthognathic intervention with regard to a patient’s psychosocial well-being, a control group matched to the treatment group should be included in such a study.

Complications

Generally, orthognathic treatment has a low morbidity [83]. Serious complications are relatively rare, and the most commonly encountered complications are post-operative infection and somatosensory disturbances (*Table 5*). Complications following OS depend on surgery procedures, surgeons’ experience, and individual biological parameters such as age, gender, body mass-index, etc. [41,84,85]. Teltzrow et al. reviewed the literature for complications following mandibular osteotomies and reported infection in 2.8% and inferior alveolar nerve damage in 2.1% [86]. Often the somatosensory disturbances present as paraesthesia and anaesthesia lasting up to 1 year after OS [87]. In spite of this, the studies in *Table 5* do not distinguish between temporary or permanent complications following OS. The relative high percentage of neurosensory disturbances can be due to temporary disturbances and not persisting somatosensory changes. One study showed that the percentage of patients with somatosensory changes fell by 75% from 1 year to 3 years following OS [88]. Thygesen et al. investigated the somatosensory changes in patients’ functional abilities 1 year after Le Fort I osteotomy. Three patients out of 25 reported that the somatosensory change affected their function. Nevertheless, all patients were satisfied and would submit to OS again [42]. Panula et al. reported that older patients appeared to suffer more from neurosensory problems than younger patients [41,84]. Other common complications are

dental injuries, vascular haemorrhage, septum dislocation, bone necrosis, oronasal fistulae, and chronic sinusitis [41,87].

Table 5. Complications following orthognathic surgery.

| Author | Year of publication | Study group (number of patients) | Procedure (number) | | Complications (%) | | | | | | | | Postoperative period (months) |
|---------------------------|---------------------|----------------------------------|--------------------|----------|-------------------|--------------------------------------|-----------------|-----------|---------------------|---------|------------------------|-----------|-------------------------------|
| | | | Maxil | Mandible | Infection | Nerve injuries/somatosensory changes | TMJ dysfunction | Fractures | Condylar resorption | Relapse | Respiratory difficulty | Neck pain | |
| Ianetti et al. [24] | 2013 | 3236 | 2,783 | 2,912 | 2 | 19 | 11 | 1 | Unknown | Unknown | Unknown | Unknown | 12 |
| Panula et al. [25] | 2001 | 655 | *146 | 612 | 4 | 35 | 29 | Unknown | 11 | 11 | Unknown | Unknown | 120 (mean 1.2 years) |
| Chow et al. [26] | 2007 | 1294 | *1,174 | 1,736 | 7 | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | > 94 |
| Kim et al. [27] | 2007 | 301 | *78 | 252 | Unknown | 65 (N=196) | Unknown | Unknown | Unknown | Unknown | 20 (n=63) | 9 (n=26) | 96 ? |
| Teltzrow et al. [28] | 2005 | 1264 | 971 | 293 | 3 | 2 | Unknown | 1 | Unknown | Unknown | Unknown | Unknown | ? |
| Al-Bishri et al. [29] | 2004 | 43 | | 43 | Unknown | 12 | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | > 12 |
| Acebal-Bianco et al. [30] | 2000 | 1,108 | | 802 | Unknown | 6 | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | ? |
| Thygesen et al. [31] | 2008 | 47 | | 47 | Unknown | 69 (25 yes/11 no) | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | 12 |
| Thygesen et al. [32] | 2009 | 25 | 25 | | Unknown | 7-60 | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | 12 |
| Spaey et al. [33] | 2005 | 810 | 275 | 1236 | 7 | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | Unknown | 1.3 |

Al-Bishri et al. showed that outcome in function and appearance outweighed the somatosensory changes [55]. In conclusion, orthognathic surgery is a very safe procedure.

Larsen et al. investigated the satisfaction following OS using the social media Facebook. Eighty-six percent of the patients were satisfied, and eighty-nine percent of the patients would recommend the surgery to others [37]. However, 65% of the patients replied that they had a somatosensory change. It is interesting to use the social media as a platform for investigation of different health problems. A lot of health care treatments are discussed in the social media, which shows that the media can play an important role in health studies.

Cost

Concern regarding cost-effectiveness is a relevant when considering the treatment of patients with dentofacial deformities. It is important to balance the costs incurred as a result of OS with the costs that may be incurred if OS was not

performed. If the orthognathic treatment is not performed, adverse dental effects may result in costs due to dental rehabilitation. Furthermore, psychosocial problems may result in costs incurred from psychologists, psychotropic drugs, etc. Only, a few studies have evaluated the actual costs following OS. Panula et al. showed that the average total cost was \$ 6,206, which depended on the type of deformity and surgical procedure [57]. In addition the cost of OS depends on demographic variations. In Denmark, all orthognathic treatment procedures are performed in the public sector, whereas in other countries the procedures are performed in both the private and public sectors. In spite of this, the literature shows a limit to the actual monetary costs of OS treatment.

Studies show that health care systems and insurance coverage play an important role with regard to acceptance of OS treatment. The level of coverage varies according to insurance and health care systems, and the size of the reimbursement has a high impact on a patient's decision

regarding OS. Zins et al. investigated the incidence of orthognathic treatments procedures and showed a reduction over a period of 5 years. According to the surgeons and orthodontists, the reduction was in approximately 90% of cases related to the reimbursement. Thus, the study was a retrospective questionnaire, the response rate was low, and the evaluation was from the professionals' point of view [48].

Indications and motivations for undergoing OS have been described, but only a few studies have investigated and compared patients who accept OS with those who decline OS [35,89]. Hågensli et al. showed that more than half of the patients who did not undergo OS reported that they declined OS because of a lack of severity of the functional problems and/or the risk of side effects. Patients who underwent OS reported that they chose OS in order to improve functional problems, tooth position, and facial appearance [35]. Bailey et al. reported that reasons for declining OS were influenced by factors other than clinical characteristics [46]. These factors could probably include monetary cost.

Literature search strategy

“The commissioning guide: Orthognathic Procedures” from the British Association of Oral and Maxillofacial Surgeons and the Danish Health Legislation were used as the background for this review [13,38]. A web-based search was conducted to obtain an objective guideline for visitation methods, indications, and outcomes following OS. The search strategy yielded 16 publications that have been discussed (Table 1). Table 1 shows search procedures with different MeSH terms and time limits. We choose the search method that gave the smallest number of publications. An outcome with a lot of publications could have resulted in bias with exclusion of relevant publications because the information provided was too comprehensive. The hand-search yielded eight publications, and thus 24 articles were included.

Conclusion

A web-based search regarding the indications for OS showed that the main indications were functional oral problems and aesthetics. All the represented data regarding the indications were based on questionnaires filled out by orthognathic patients. The data were subjective, and only based on the patient's point of view. No studies regarding the indications from a maxillofacial surgeon's or other professionals' points of view were found in the literature. The literature shows a lack of professionals' indications for performing OS according to patients' health and/or functional status. The Danish health care system and different health care insurance schemes have more or less well-defined guidelines for orthognathic interventions [13]. The qualitative parameters of health can be very difficult to graduate and explain to the patient prior to OS. Can the maxillofacial surgeon predict that the patient will become psychosocially depressed if OS is not performed?

The literature shows an increase in the number of OS procedures performed in older patients, which may be explained by the indications for OS.

In addition, motives for the acceptance of OS include expedience of the orthodontic treatment and the best functional

and aesthetic outcome. Reasons for refusing OS include potential morbidity and the related cost. Health care systems and insurance coverage have an important role with regard to acceptance [48,90]. The amount of coverage varies according to insurances and health care systems, and the level of reimbursement can have an impact on whether OS procedures are performed.

The reimbursement and the monetary cost as an explanation for declining OS is a serious issue that can affect the quality of life and function of patients with dentofacial deformities. With the current focus on optimal health care, it is extremely frustrating that patients can be denied OS for economic reasons. The high satisfaction and the improvement in both functional and psychosocial status following OS indicate just how important OS is.

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