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*Review*

# Current Trends in Skeletal Borderline Patients: Surgical versus Orthodontic Treatment Decisions—What Is the Evidence?

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**Abstract:** *Background*: The aim is to assess the current evidence-based knowledge about treatment decisions for skeletal malocclusion in adult borderline patients. *Methods*: A literature search was conducted through three databases. Inclusion criteria were restricted to systematic reviews, prospective, retrospective, and control studies. Only articles comparing orthodontic camouflage and orthognathic surgical treatment for Class II and Class III malocclusions in adult patients were selected to be reviewed. *Results*: Seven articles concerning Class II and nine concerning Class III met the inclusion criteria. Scientific evidence was poor due to low methodological quality. *Conclusions*: Surgical treatment was found to better improve skeletal and soft-tissue cephalometric values, whereas camouflage treatment mainly involved dentoalveolar movements. Aesthetic changes, as perceived by the patient, were not significantly different in the two groups. Recently improved surgical techniques, differing from those described in the analyzed articles, may provide similar or more stable outcomes compared with orthodontic-only treatment. Although some cephalometric variables can be helpful, the most important parameters for treatment selection are the patient's presenting complaint and their self-image perception. Further studies with larger sample sizes and similar pretreatment conditions, and considering patient self-evaluation of esthetics and function, should be undertaken.

**Keywords:** borderline; camouflage; Class II; Class III; orthognathic surgery; skeletal malocclusion; orthodontics; malocclusion; orthodontic camouflage

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## 1. Introduction

Skeletal balance, functional occlusion, and facial harmony are common goals in orthodontics and orthognathic surgery. However, the boundary line for the decision between orthodontic and surgical treatment remains very controversial in adult borderline patients. Up to 10% of orthodontically treated patients are borderline and may have been treated either way (both with camouflage and orthognathic surgery) [1]. Cassidy [2] defines "borderline cases" as those patients who were similar in respect to the characteristics on which the orthodontic/surgical decision appeared to have been based. The decision-making process is influenced by different variables, such as facial esthetics, patient desires, values and cultural differences, orthodontist background and preferences, surgical expertise, and financial considerations [3,4]. The introduction of 3-Dimensional (3D) imaging and computer-aided surgical planning have improved accuracy and prediction in surgical outcomes [5,6]. Moreover, they have enhanced new protocol regimes that are promising in that they can potentially reduce the overall treatment time and obtain immediate improvement in facial esthetics, greater patient satisfaction, and improved cooperation during postoperative orthodontic treatment [7,8]. Conversely, the recent application of Temporary Anchorage Devices (TADs) and 3D technologies have significantly improved the orthodontic field by facilitating dental movements that were previously only achievable by means of orthognathic surgery [9]. Complex malocclusions can be resolved through orthodontic treatment by means of TADs, driving the more complicated movements such as molar intrusion, distalization, and molar protraction [9]. However, according to a recent systematic review on Class III camouflage orthodontic treatment by Sakoda et al., most of this recent information is derived from case reports and expert opinions, which lack stronger evidence and predictable clinical reproducibility [10]. In addition, recent interest in patient satisfaction during health care provision has grown significantly. Patients' perceptions and expectations have become increasingly important in justifying health services delivery and ensuring overall health care quality [9]. A recent systematic review concludes that final esthetic outcome, perceived social benefits, type of orthognathic surgery, sex, and changes in patient self-concept during treatment were associated with satisfaction. Treatment length, sensation of functional impairment and/or dysfunction after surgery, and perceived omitted information about surgical risks were associated with patient dissatisfaction [11].

Historically, Proffit and Ackerman introduced the "envelope of discrepancy" concept. The Profitt diagram illustrates the quantitative relationship of three basic treatment possibilities for a skeletal discrepancy. When a moderate discrepancy exists and there is no growth potential, orthodontic camouflage could be applied by displacing the teeth to obtain proper function despite the jaw relationship, which produces a dental compensation for the skeletal discrepancy. However, the envelope outlines the sagittal limits of hard tissue changes towards an ideal occlusion, but does not include transversal limits in skeletal discrepancy, soft tissue evaluation and patients' complaints, resulting in an incomplete method of treatment decision in borderline cases [4,12].

It is suggested that orthodontic camouflage of skeletal malocclusions would have acceptable results if there were an average or short facial pattern, mild anteroposterior jaw discrepancy, dental crowding lower than 4–6 mm, normal soft tissue features (nose, lips, chin), and no transverse skeletal problems. Poor results would be expected with the following: a long vertical facial pattern, moderate or severe antero-posterior jaw discrepancy, dental crowding greater than 4–6 mm, exaggerated facial features, and a transverse skeletal discrepancy. As a rule, skeletal Class II conditions are more suitable for a camouflage correction compared with those of skeletal Class III [12,13].

At present, few studies have compared the outcomes between surgical and orthodontic camouflage treatments for adult skeletal borderline patients. Previous research has adopted different hard and soft-tissue cephalometric parameters both in Class II and Class III skeletal borderline to define criteria for pre-treatment selection. However, no consensus was obtained concerning the best assessment method. The current data are mostly derived from retrospective studies with moderate to low scientific evidence. No randomized clinical trials have been undertaken comparing the surgical and the orthodontic camouflage options, owing to the difficulty in patient recruitment, for ethical reasons. Prospective studies are rare due to the excessive cost and study length. Finally, a few studies have reported long-term follow up that could evaluate which treatment modality would be more stable overtime [14].

The primary aim of this narrative review is to present a complete and updated perspective of current evidence-based knowledge about the treatment options in skeletal adult borderline patients. Furthermore, it will highlight new areas of investigation into the decision-making process in borderline patients, where studies have larger sample sizes, similar pre-treatment conditions, and appropriate periods of follow-up.

The authors are aware that their analyses may be affected by inadvertent biases, as this is not a systematic review, even though every effort has been made to analyze the literature as impartially and objectively as possible.

## 2. Materials and Methods

A literature search was conducted in Pub Med, Google Scholar and through the American Association of Orthodontists' library. We searched literature up to 1 April 2021. An English language filter was applied. Subsequently, further articles were selected using references supplied by the chosen articles.

The following keywords were searched as Medical Subject Headings (MeSh) terms and as free text words: orthognathic surgery, orthodontics, camouflage, malocclusion, Class II, Class III, borderline. In the article selection, only mild to moderate skeletal Class II and Class III adult patients were included. In current literature, the decision-making criteria in treatment planning for these patient remains very controversial: some authors [2,14–19] suggest using cephalometric analyses to identify the borderline patients (Table 1).

**Table 1.** Cephalometric values used to identify skeletal borderline patients.

| **Skeletal and soft tissue measurements:** |
| --- |
| - ANB angle |
| - Wits appraisal |
| - Skeletal convexity (NA-Pg) |
| - Maxilla–mandibula ratio (M–M ratio) |
| - Mandibular length |
| - Lower gonial angle |
| - SN length |
| - Facial height |
| - Holdaway angle |
| - Soft tissue convexity including the nose (NO-Pn-PogO) |
| - Soft tissue convexity excluding the nose (NO-Sn-PogO) |
| **Dental measurements:** |
| - OVJ |
| - Molar relationship |
| - Interincisal angle |
| - Lower incisal angle |

Only articles that compared orthodontic camouflage and orthognathic surgical treatment for non-growing patients with skeletal Class II and Class III borderline malocclusions were selected to be reviewed. The inclusion criteria were restricted to systematic reviews, prospective and/or control studies, retrospective, and/or control studies.

Case reports, case series, and review articles were excluded, as well as studies involving syndromic patients or deformities, transverse discrepancies, skeletal and dental asymmetries, and tooth size discrepancies. Conversely, studies evaluating criteria for pre-treatment selection, comparative treatment outcomes and long-term follow-up data were included.

Two authors independently performed the literature search and selection of studies through title and abstract. When the abstract was not available the article was excluded. In the selected articles, the full text was screened. Finally, the results were compared and any disagreement was discussed with a third author.

## 3. Review

### *3.1. Class II*

There are two treatment options in Class II borderline post-pubertal correction: orthodontic camouflage with or without genioplasty and orthodontic-surgical correction through single jaw or bimaxillary surgery. In orthodontic camouflage treatment, the goal is to mask the skeletal discrepancy through dental compensation. When extractions are required, they are generally done in the upper arch (first premolars) to correct the overjet and/or the protrusion of the upper incisors [14].

In addition, the use of functional appliances, advocated in younger patient to enhance mandibular growth modification, have been reported in adult patients to change dental position only [20,21]. Conversely, orthodontic–surgical treatment aims to correct the underlying skeletal deformity. Dental decompensation is a fundamental prerequisite in the orthodontic-first approach, while with a surgery-first protocol, it should be considered an absolute objective of post-surgery orthodontics for treatment stability. Previous experience suggests that there are flaws in the process of selecting treatment options [21].

According to the available literature, there are no clear guidelines on the best treatment approach for Class II adult borderline patients [14].

Study Design and Treatment Interventions

Concerning skeletal Class II patients, we found 6 non-randomized clinical trials (N-RCT) and one systematic review (Table 2). All studies are retrospective cephalometric studies which compare orthodontic-only intervention and orthodontic–surgical intervention through skeletal, dental, and soft tissue cephalometric changes from baseline to the end of treatment (Table 3). Some studies added dental cast measurements and patient and/or clinician retrospective evaluation of outcomes of facial soft tissue by the clinician and/or patient satisfaction. Four studies [2,20,22,23] reported a variable period of follow-up. The most represented malocclusion was Class II Division 1, and the primary surgical intervention undertaken was mandibular advancement. Compared to other surgery procedures, bimaxilary surgery was reported as a treatment option in very few studies.

In a 1992 retrospective study, Proffit et al. [20] compared the short-term (1-year post treatment) outcomes (33 patients treated with orthodontics-only, and 57 with surgery and orthodontics) by evaluating whether the final measurement values fell within the normal range, as well as the quantitative amount of correction produced relative to an "ideal" value. Also, a group of judges rated esthetic changes from frontal and profile photographs. Whether or not most patients in both groups achieved acceptable changes in the occlusal parameters, overall surgical treatment resulted in greater improvement for most criteria (cephalometric skeletal, dental, and soft tissue); in particular, a significantly greater percentage of the "ideal" goal was achieved for the ANB Angle, maxillary incisor position, soft tissue A-B difference, and overjet (OVJ). Esthetic changes determined by orthodontic treatment were small (ratings remained unchanged), whereas those determined by surgical treatment were substantial, especially in patients with the lowest initial ratings. It is important to point out that in this study no attempt was made to match the groups; at baseline, the orthodontic group presented less severe skeletal conditions and a more pleasant facial soft tissue. In addition, orthodontic treatment strategy and mechanics were different among the groups, and this could account for different outcomes at the end of treatments. Camouflage treatment seems more effective in those patients who initially have pleasant facial esthetics, as orthodontic treatment alone can be accomplished without detriment to facial esthetics. The more severe the mandibular deficiency, the greater the OVJ and the poorer the facial esthetics, the more likely it is that the patient benefits from surgery.

In 1993, Cassidy et al. [2] compared long-term effects of orthodontic and surgical treatment. By using a discriminant analysis, they identified two homogeneous groups of patients with moderately severe skeletal Class II malocclusion, morphologically similar, thus susceptible both to orthodontics-only camouflage treatment (27 subjects, with/without extractions) or mandibular advancement (28 subjects). They evaluated skeletal and dental changes through lateral cephalograms and dental cast analysis, assessment of profile esthetics, and temporomandibular functionality. Results showed no significant differences in patient profile evaluation and no significant differences in craniomandibular functionality and incisor stability. At recall (7.1-years after orthodontic treatment and 4.7 years after surgery), the camouflage treatment group's relapse was minor and concerned incisor uprighting and a loss of some overbite (OVB) correction. Decision analysis and utility scales were used to calibrate patient preference by measuring the risk that borderline patients were willing to assume to achieve a desired outcome; it was found that orthodontic treatment had a better payoff, whereas surgery was preferable in more severe skeletal discrepancies.

**Table 2.** Sample size, mean age and surgical procedure considered in each study.

| Article Selected | Sample Size | Mean Age (Years) | Surgery |
|---|---|---|---|
| Proffit et al., 1992 | 1 | 22 | Mandibular setback |
| Cassidy et al., 1993 | 53 | Not provided (adult patient specified) | Mandibular advacement |
| Mihalik et al., 2003 | 74 | 26.8 | Not provided |
| Ruf et al., 2004 | 69 | 23.9 | Mandibular advancement with a retromolar sagittal split osteotomy without genioplasty |
| Kinzinger et al., 20 | 60 | 20.6 | Bilateral sagittal split osteotomy of the mandible without genioplasty |
| Chaiyongsirisern et al., 2009 | 32 | 23 | Mandibular advancement with bilateral sagittal split osteotomy |
| Raposo et al., 2018 | Specified in the primary study | Specified in the primary study | Specified in the primary study |
| Kerr et al., 1992 | 40 | 16.7 | Not provided |
| Stellzig-Eisenhauer et al., 2002 | 175 | Not provided (adult patient specified) | Not provided. |
| Rabie et al., 2008 | 25 | 17.8 | Bimaxillary surgery, mandibular surgery only, and maxillary surgery only |
| Kochel et al., 2011 | 69 | 25.25 | Not provided. |
| Benyahia et al., 2011 | 57 | Not provided (adult patient specified) | Not provided |
| Martinez et al., 2017 | 156 | Not provided (age over 20 years specified) | maxillary advancement, mandibular setback, and bimaxillary surgery |
| Eslami et al., 2018 | 45 | 24.15 | Setback of the mandible, maxillary advancement, or bimaxillary surgery. |
| Troy et al., 2009 | 79 | Not provided (complete growth spurt specified) | Mandibular setback, maxillary advancement, or both |
| Georgalis et al., 2015 | 67 | Not provided (adult patient specified) | maxillary advancement, and mandibular setback |

**Table 3.** Cephalometric values and ranges for decision-making in the selected articles.

| Article Selected | Cephalometric Values (Pre-Treatment Characteristics of Subjects—Means) | | | Value Range | | |
|---|---|---|---|---|---|---|
| Proffit et al., 1992 | | Camouflage | Surgery | OVJ: 1–4<br>OVB: 1–4<br>ANB: 1–5<br>Mandibular Plane: 27–37<br>Maxillary Incisor (degrees): 16–28<br>Mandibular Incisor (degrees): 19–31<br>Soft tissue A′-B′ difference: −2 to 8<br>Buccal interdigitation (L): −2 to 2<br>Buccal interdigitation (R): −2 to 2<br>Crossbite: absent | | |
| | OVJ | 6.6 | 9 | | | |
| | ANB | 5.1 | 5.8 | | | |
| | Mandibular plane angle | 34 | 32.2 | | | |
| Cassidy et al., 1993 | | Camouflage | Surgery | Not provided | | |
| | Overjet | 7 | 8.3 | | | |
| | Overbite | 3.2 | 2.5 | | | |
| | Wits A/B | 3.5 | 5.2 | | | |
| | Molar relationship | −0.9 | −2.2 | | | |
| | L1-APog (mm) | 0.5 | 0.4 | | | |
| | PNS-A (mm) | 50.9 | 51.8 | | | |
| | N-Me (mm) | 121.2 | 121.8 | | | |
| | S-Go (mm) | 77.3 | 76 | | | |
| | ANB | 5.5° | 6.7° | | | |
| | Y axis | 58.5° | 58.6° | | | |
| | GoGn-SN | 33° | 33.9° | | | |
| | 1/1 | 125.5° | 121.9° | | | |
| | U1-SN | 103.6° | 106.2° | | | |
| | IMPA | 97.8° | 98° | | | |
| Mihalik et al., 2003 | | Camouflage | Mandibular advancement | Not provided | | |
| | Overjet (mm) | 5.82 | 7.9 | | | |
| | Overbite (mm) | 4.3 | 9.34 | | | |
| | MxInc-SN | 105.07° | 103.97° | | | |
| | MdInc to MP | 103.48 ° | 100.35° | | | |
| | ANB | 5.59° | 6.57° | | | |
| | Palatal plane | 6.66° | 8.54° | | | |
| | Mandibular plane | 33.96° | 34.20° | | | |
| | TFH | 116.20 mm | 120.51 mm | | | |
| | Ramus ht—Co-Go | 55.31 mm | 59.91 mm | | | |
| | Mand length—Co-Pg | 109.58 mm | 111.83 mm | | | |
| Ruf et al., 2004 | | Herbst | Surgery | | Herbst | Surgery |
| | ANB | 5.18 | 6.04 | OVJ(mm) | −12.25 | −11.75 |
| | Wits (mm) | 2.55 | 4.72 | | | |
| | Overbite (mm) | 4.43 | 4.23 | OVB(mm) | −6.25 | −9.5 |
| | Spa-Gn × 100/N-Gn (index) | 54.55 | 54.84 | | | |
| | Spp-Go′ × 100/S-Go′ (index) | 41.4 | 46.89 | ANB(°) | −3 | −5.25 |
| | NAPg (°) | 172.08 | 170.87 | | | |
| | NS/Sn/PgS (°) | 159.68 | 158.12 | NAPg(°) | 4.75 | 12 |
| | NS/No/PgS (°) | 126.3 | 121.35 | | | |

**Table 3.** *Cont.*

| Article Selected | Cephalometric Values (Pre-Treatment Characteristics of Subjects—Means) | | | | Value Range | |
|---|---|---|---|---|---|---|
| Kinzinger et al., 2009 | | Orthopedic | Extraction | Surgery | Not provided | |
| | OVJ (mm) | 7.59 ± 2.57 | 3.95 ± 2.73 | 7.21 ± 3.06 | | |
| | OVB (mm) | 2.70 ± 2.29 | 1.21 ± 2.16 | 4.05 ± 3.54 | | |
| | SNA (°) | 81.32 ± 4.10 | 82.99 ± 3.38 | 82.53± 4.06 | | |
| | SNB (°) | 74.80 ± 4.31 | 76.90 ± 3.57 | 75.22 ± 4.36 | | |
| | Ar-Go-Me (°) | 119.30 ± 9.89 | 127.99 ± 6.19 | 121.73 ± 10.51 | | |
| | UP1/SN | 105.59 ± 9.06 | 104.38 ± 6.69 | 103.39 ± 13.76 | | |
| | L01/MP | 100.56 ± 7.05 | 92.79 ± 7.42 | 99.10 ± 9.51 | | |
| | N-A-Pog | 171.34 ± 6.61 | 170.37 ± 6.00 | 170.49 ± 8.26 | | |
| | N′-Pn-Pog′ | 123.63 ± 5.08 | 129.34 ± 4.86 | 122.76 ± 5.78 | | |
| | N′-Sn-Pog′ | 153.30 ± 6.25 | 157.24 ± 4.38 | 154.14 ± 8.00 | | |
| Chaiyongsirisern et al., 2009 | | Herbst | Surgery | | Not provided | |
| | OVJ (mm) | 8 ± 2.07 | 9.9 ± 2.60 | | | |
| | OVB (mm) | 4.88 ± 0.47 | 4.94 ± 1.44 | | | |
| | ANB (°) | 5.06 ± 2.50 | 5.13 ± 1.54 | | | |
| | Wits (mm) | 2.13 ± 1.96 | 3.64 ± 2.65 | | | |
| | Spa-Gn × 100/N-Gn (index) | 53.29 ± 2.13 | 52.08 ± 2.52 | | | |
| | Spp-Go × 100/S-Go′ (index) | 48.63 ± 4.24 | 47.05 ± 4.26 | | | |
| | NAPg | 172.00 ± 7.25 | 170.81 ± 5.04 | | | |
| | NS/Sn/PgS | 160.75 ± 7.46 | 158.41 ± 5.12 | | | |
| | NS/No/Pgs | 135.13 ± 6.03 | 130.90 ± 4.25 | | | |
| Raposo et al., 2018 | Not provided | | | | Not provided | |
| Kerr et al., 1992 | | Surgery | Orthodontics | | | |
| | SNA (°) | 79.5 ± 4.0 | 81.2 ± 2.4 | | | |
| | SNB (°) | 86.4 ± 5.2 | 83.8 ± 3.3 | | | |
| | ANB (°) | 6.9 ± 2.9 | −2.6 ± 2.6 | | | |
| | M/M ratio | 0.78 ± 0.07 | 0.89 ± 0.08 | | ANB Angle | −4° |
| | BaSN | 126.6 ± 6.1 | 126.3 ± 6.9 | | M/M ratio | 0.84 |
| | Gonial angle | 133.3 ± 8.3 | 132.2 ± 5.5 | | L1/Mand° | 83° |
| | MMPA | 25.3 ± 7·8 | 29.0 ± 4.1 | | Holdaway angle | 3.5° |
| | Facial proportions | 55.9 ± 3.6 | 56.2 ± 2.3 | | | |
| | U1/max° | 115.4 ± 7.8 | 112.9 ± 7.3 | | | |
| | L1/mand° | 78.5 ± 9.9 | 85.4 ± 5.2 | | | |
| | Y-axis | 61.9 ± 4.5 | 64.0 ± 3.3 | | | |
| | Holdaway angle | 0.9 ± 4.4 | 6.1 ± 5.0 | | | |
| Stellzig-Eisenhauer et al., 2002 | | Nonsurgical | Surgical | | Individual score = −1.805 + 0.209 × Wits + 0.044 × SN + 5.689 × M/M ratio − 0.056 × Golower); if: >−0.023 Camouflage <−0.023 Surgery | |
| | SN (mm) | 68.77 ± 4.33 | 67.41 ± 5.18 | | | |
| | Golower (°) | 75.46 ± 5.14 | 80.37 ± 6.56 | | | |
| | 1-ML (°) | 86.15 ± 6.97 | 78.02 ± 9.19 | | | |
| | Wits (mm) | −4.61 ± 1.70 | −12.21 ± 4.25 | | | |
| | ANB (°) | −0.06 ± 2.09 | −4.22 ± 3.19 | | | |
| | M/M ratio | 0.92 ± 0.08 | 0.80 ± 0.07 | | | |
| | NAPog (°) | −0.90 ± 2.89 | −5.23 ± 3.64 | | | |
| | 1/1 (°) | 133.09 ± 9.36 | 139.36 ± 10.83 | | | |
| Rabie et al., 2008 | | Orthodontic | Surgery | | | |
| | ANB (°) | −1.46 ± 2.06 | −2.12 ± 2.51 | | | |
| | Wits (mm) | −8.46 ± 2.73 | −10.86 ± 5.61 | | | |
| | M/M ratio | 0.85 ± 0.07 | 0.83 ± 0.10 | | | |
| | NAPog (°) | −3.71 ± 5.09 | −3.61 ± 7.07 | | Holdaway >12° | Camouflage |
| | Go lower (°) | 75.58 ± 4.77 | 78.49 ± 7.01 | | Holdaway <12° | Surgery |
| | Facial prop | 55.43 ± 2.71 | 56.28 ± 2.49 | | | |
| | U1-SN (°) | 111.76 ± 6.02 | 108.74 ± 11.07 | | | |
| | L1-ML (°) | 93.74 ± 7.30 | 86.91 ± 10.97 | | | |
| | U1-L1 (°) | 120.65 ± 7.89 | 128.71 ± 10.95 | | | |
| | Holdaway angle | 14.57 ± 4.07 | 10.14 ± 4.26 | | | |

**Table 3.** *Cont.*

| Article Selected | Cephalometric Values (Pre-Treatment Characteristics of Subjects—Means) | | | Value Range |
|---|---|---|---|---|
| Kochel et al., 2011 | | Nonsurgical | Surgical | Individual score = −10.988 + 0.243 × Wits + 0.055 × M/M ratio + 0.068 × NSAr −0.589 × mand MLD; if: >0.251 Camouflage <0.251 Surgery |
| | SN (mm) | 66.18 ± 1.21 | 68.70 ± 0.76 | |
| | Golower (°) | 75.40 ± 1.02 | 76.25 ± 1.17 | |
| | 1-ML (°) | 89.90 ± 1.05 | 84.34 ± 1.19 | |
| | Wits (mm) | −4.56 ± 0.30 | −9.22 ± 0.49 | |
| | ANB (°) | 0.49 ± 0.44 | −3.68 + 0.53 | |
| | M/M ratio (%) | 92.71 ± 1.35 | 81.26 ± 1.20 | |
| | ANPog (°) | −0.51 ± 0.54 | −5.27 ± 0.62 | |
| | 1/1 (°) | 132.64 ± 1.55 | 135.42 ± 1.48 | |
| | NSAr (°) | 127.06 ± 1.20 | 121.83 ± 0.78 | |
| | Mand MLD (mm) | 0.45 ± 0.11 | 1.35 ± 0.16 | |
| Benyahia et al., 2011 | | Surgery | Orthodontics | Holdaway angleIf >7.2°, camouflage If <7.2°, surgery |
| | Goinf (°) | 78.01 ± 6.06 | 78.08 ± 4.66 | |
| | L1-ML (°) | 83.75 ± 9.91 | 91.00 ± 6.06 | |
| | U1-SN (°) | 108.27 ± 10.23 | 108.55 ± 6.70 | |
| | Ao-Bo (mm) | −10.44 ± 3.74 | −7.59 ± 1.95 | |
| | ANB (°) | −4.41 ± 3.13 | −1.01 + 2.01 | |
| | GoMe/SN | 1.143 ± 0.089 | 1.12 ± 0.07 | |
| | NaPog (°) | −5.49 ± 3.65 | −0.89 ± 2.48 | |
| | U1-L1 (°) | 134.62 ± 13.19 | 124.02 ± 8.98 | |
| | NSAr (°) | 122.64 ± 5.31 | 123.74 ± 6.17 | |
| | Axe Y | 54.57 ± 4.30 | 58.58 ± 3.24 | |
| | Holdaway angle | 3.04 ± 5.43 | 11.32 ± 3.46 | |
| Martinez et al., 2017 | | Camouflage | Surgery | Not provided |
| | SNA (°) | 80 ± 4.2 | 80.9 ± 4 | |
| | SNB (°) | 82 ± 4 | 84.1 ± 4.2 | |
| | ANB (°) | −1.9 ± 2.3 | −3.2 ± 3.1 | |
| | Wits (mm) | −7 ± 1.9 | −11.2 ± 3.2 | |
| | FA (°) | 66.7 ± 3.9 | 66.4 ± 4.4 | |
| | MPA (°) | 33.4 ± 5.9 | 34.8 ± 6.6 | |
| | UII (°) | 114 ± 5.5 | 112.7 ± 5.5 | |
| | LII (°) | 86.2 ± 6 | 77.5 ± 8.7 | |
| | IA (°) | 133.3 ± 7.7 | 140 ± 10.4 | |
| Eslami et al., 2018 | | Camouflage | Surgery | Holdaway > 10.3° Camouflage Wits appraisal > −5.8 mm Holdaway < 10.3° Surgery Wits appraisal < −5.8 mm |
| | ANB (°) | −1.1 ± 1.2 | −2.1 ± 1.2 | |
| | Wits Appraisal (mm) | −4.8 ± 1.8 | − 6.8 ± 1.7 | |
| | NAPog (°) | −3.6 ± 3.2 | −6.3 ± 3.9 | |
| | Go lower (°) | 77.4 ± 7 | 80.6 ± 4 | |
| | Y axis | 68.6 ± 8.6 | 68.1 ± 3.8 | |
| | U1-SN (°) | 107.8 ± 6.2 | 106.2 ± 8 | |
| | L1-ML (°) | 90 ± 9.2 | 85.9 ± 7.2 | |
| | U1-L1 (°) | 132.4 ± 10.3 | 132.8 ± 11.2 | |
| | Holdaway angle | 11.9 ± 2.8 | 8.7 ± 3.5 | |
| Troy et al., 2009 | | Surgery | Camouflage | Not provided |
| | ANB (°) | −4.47 | −1.43 | |
| | Wits (mm) | −10.87 | −6.91 | |
| | SN-GoGn (°) | 29.78 | 30.01 | |
| | Lower anterior face height % | 55.84 | 55.13 | |
| | OVJ (mm) | −3.27 | −0.78 | |
| | U1-SN (°) | 108.87 | 104.96 | |
| | L1-GoGn (°) | 83.5 | 91.07 | |

**Table 3.** *Cont.*

| Article Selected | Cephalometric Values (Pre-Treatment Characteristics of Subjects—Means) | | | Value Range | | |
|---|---|---|---|---|---|---|
| | | Surgery | Camouflage | Treatment change (T1-T3) for borderline surgery and camouflage groups | | |
| | | | | | Surgery | Camouflage |
| Georgalis et al., 2015 | ANB | −3.8 ± 2.4 | −1.2 ± 2.0 | ANB | 4.3 * | 0.8 * |
| | Wits | −11.5 ± 3.6 | −7.2 ± 2.8 | Wits | 5.2 * | 2.1 * |
| | OVJ | −2.7 ± 2.2 | −0.2 ±1.6 | OVJ | 5.2 * | 3.1 * |
| | U1-SN | 109.0 ± 8.0 | 107.2 ± 6.7 | U1-SN | 3.9 | 4.3 |
| | L1-Md Plane | 79.8 ± 8.3 | 84.3 ± 6.8 | L1-Md Plane | 6.6 * | −1.7 * |
| | Interincisal | 135.0 ± 12.2 | 133.3 ± 9.2 | Interincisal | −13.6 * | −0.6 * |

* Statistically significant difference between treatment methods.

In a 2003 N-RCT, Mihalik et al. [22] evaluated long-term (from 1-year up to >5 years) skeletal and soft tissue changes, occlusal stability, and patient satisfaction with treatment in a sample of 31 adult patients treated with orthodontic camouflage (involving dental extractions) or orthognathic surgery. Data collection included cephalometric variables, dental casts, intraoral and extraoral photographs, self-evaluation forms, and satisfaction questionnaires. Results showed that OVB change was similar between the groups, and it was related to incisor over-eruption and post-treatment incisor irregularity. Surgery patients were twice as likely to have a long-term increased OVJ, which was due to dental compensation related to late soft tissue changes and post-surgery skeletal remodeling. In this study, camouflage patients have, in general, less severe problems than those treated surgically, as well as fewer functional and/or temporomandibular joint problems. The greater amount of change produced by surgery contributes to the greater prevalence of long-term changes in surgery patients. The overall satisfaction with treatment was comparable within groups, but patients who underwent mandibular advancement were significantly more positive about their appearance. Mihalik, therefore, suggested that the ideal patient for camouflage should have good initial facial esthetics, with an increased OVJ related to maxillary incisor protrusion rather than skeletal mandibular retrusion. A greater mandibular deficiency and a large OVJ have an increased need for surgery in order to obtain satisfactory clinical correction. In conclusion, the way that patients perceive the severity of their problem is a key in the decision-making process to elect for surgery rather than a camouflage plan or no treatment.

In a 2004 N-RCT by Ruf et al. [24] the efficacy of the Herbst appliance (a fixed Class II corrector), used in 23 adult patients with borderline skeletal Class II Division 1, was compared to a similar group of 46 adult patients treated with non-extraction mandibular advancement by means of bilateral sagittal split osteotomy (BSSO). The surgery group showed greater changes in mandibular advancement, with reduction in SNB, SNPg, ANB, and Wits Appraisal; increased anterior facial height, profile convexity reduction, retrusion of upper lip, and Class II molar correction, whereas SNA changes were comparable for both groups. As expected, these changes showed the same direction except for the mandibular plane angle (increased in the surgery group) and the posterior facial height (smaller in the surgery group). The data suggest that, whereas occlusion can be successfully corrected by the means of a Herbst Appliance, chin projection and facial esthetics cannot. If the patient's main goal is to greatly improve facial profile, BSSO or advancement genioplasty only (if the main complaint is chin prominence) are a better option. The absence of a follow-up and over-representation of women in both samples are some important limits of this study. Moreover, it would have been useful to compare these results to those from a third group of patients, treated with an orthodontic camouflage plan involving dental extraction.

In a 2009 retrospective cephalometric study, Kinzinger et al. [21] compared skeletal, dentoalveolar, and soft-tissue profile effects of three different treatment approaches in patients with skeletal Class II Division 1 malocclusion. A group of 20 patients were treated by orthodontic camouflage with upper premolar extractions, 20 with fixed functional orthopedic appliances, and 20 with BSSO of the mandible without genioplasty (combined with orthodontics). No long-term follow-up was reported. Each patient group achieved a reduction in OVJ and no treatment-related changes in the maxillary area were noticed. Changes associated with the mandible included bony chin advancement and an increase in mandibular length in the sagittal–diagonal dimension, which was observed in the surgical and functional orthopedic groups. However, the extent of treatment-related skeletal change was only significant in the surgical group. Regarding dental outcomes, the surgical group demonstrated a significant protrusion of upper incisors—likely as part of the pre-surgical decompensation, while the orthopedic plan resulted in retrusion of maxillary incisors and proclination of mandibular incisors (camouflage); the extraction group showed retrusion of both upper and lower incisors (likely because of space closure). OVB only increased in the extraction group. Regarding soft tissue remodeling, orthognathic surgery led to the most marked profile changes, while fixed functional orthopedic appliances resulted in a moderate reduction in the soft-tissue profile convexity. Camouflage orthodontics resulted in an increase in the nasolabial angle, which is often esthetically undesirable. The authors concluded that functional treatment is suggested in mild skeletal Class II, but it does not represent an alternative to surgery when the desire for an improved chin projection is the main complaint. In the study, the sample size for each group was modest and no information is available regarding group homogeneity. The surgical group is represented exclusively by a mandibular advancement procedure so it is not known if the addition of maxillary surgery would have resulted in more significant changes in the soft-tissue balance and profile.

In 2009, Chaiyongsirisern et al. [23] retrospectively compared treatment effects and long-term stability of the stepwise Herbst Appliance and BSSO in skeletal Class II adult patients. Cephalometric data were recorded and compared at baseline (T0), after Herbst-treatment or immediately after surgery (T1), at the end of treatment (T2), and three years post treatment (T3). Both groups achieved a Class I occlusal relationship and a reduction in skeletal and soft tissue convexity at T2; however, as expected, the surgery group showed more skeletal movement and reduction in soft tissue convexity (as NAPg and NS/Sn/PgS) than did the Herbst group. Three years post-treatment (T3), no significant relapse was seen within the Herbst group when compared to the surgery group. Long-term stability in the skeletal and facial profiles was comparable in both groups. It is suggested that holding the new position for at least 6 months is the key for long-term stability in the camouflage orthopedic treatment, whereas surgery remains a better option for improving profile convexity, if the patient is willing to accept the related risks and potential complications. It would have been interesting to compare the camouflage groups to other orthodontic modalities of Class II correction, and to compare the BSSO group to a bimaxillary surgical group. Limits of this study are the small sample size and an over-representation of women in both groups.

A 2018 meta-analysis performed by Raposo et al. [14], aimed to compare dental, skeletal, and aesthetic outcomes between orthodontic camouflage and surgical–orthodontic treatment in non-growing skeletal Class II malocclusions. Seven articles were included, but only one presented moderate scientific quality. Results show that differences between treatments were not statistically significant regarding specific cephalometric values, such as SNA angle, LL to E-line (mm), convexity of skeletal profile (N-A-Pog), and convexity of the soft tissue profile excluding the nose (N′-Sn-Pog′). Surgical–orthodontic treatment was more effective for skeletal measurements (ANB, SNB and ML/NSL angles) and convexity of the soft-tissue profile including the nose (N′-Pn-Pog′). Different treatment outcomes were found significant for dental measurements (OVJ and OVB), but they were related to the differing pre-treatment severity. In future studies Pog′ should be preferred to point B which does not consider the morphology of the chin, therefore the SNB value may not reflect the actual mandibular positioning. For sagittal discrepancy, the Wits variable should be preferred to the SNB Angle because it relates the maxilla and mandible to the occlusal plane, independently of the craniofacial reference. Thus, any jaw rotation relative to the cranial reference plane does not affect the malocclusion severity [20]. In addition, the Incisor Mandibular Plane Angle (IMPA) should be analyzed to evaluate different treatment effects (extraction versus non-extraction) on lower incisor position and inclination. For sagittal esthetic evaluation, the True Vertical Subnasal Line (TVL) should be adopted because it does not vary according to the position of the chin and nose, and therefore, may be preferable to the E-line. Moreover, the Naso-Labial Angle (Cm-Sn-UL) should be added to evaluate variations in lip position related to extraction therapy. It is suggested that further studies with larger sample sizes, better methodological quality, similar pre-treatment conditions, and appropriate periods of follow-up (being the same for both treatments) be performed to overcome the limitations identified in the meta-analysis [14].

### *3.2. Class III*

Borderline Class III Camouflage treatment can be carried out by different approaches and may include dental extractions (most commonly lower premolars and lower incisors), distalization of the mandibular dentition, and use of Class III intermaxillary elastics [10]. Successful camouflage treatment consists of dentoalveolar compensations, which mask the underlying skeletal problem while allowing for an improvement in occlusion, function, and esthetics.

On the other hand, surgical–orthodontic treatment varies according to skeletal sagittal and vertical discrepancy. It could consist in one-jaw surgery: mandibular set-back or maxillary advancement, or in bimaxillary surgical procedures. Genioplasty could be combined with either surgery. The main objective of combined orthodontic and orthognathic surgery treatment is to correct the skeletal discrepancy, establish optimal function, and improve facial balance and harmony. This often involves the correction of the main dental and skeletal variables to a range of accepted cephalometric values. The surgical-first protocol, when indicated, has recently been favored over the orthodontic-first protocol in Class III conditions because it is more stable and psychologically favorable for the patient [7,8].

#### 3.2.1. Study Design and Treatment Interventions

Employing the same search criteria as for the Class II condition, the nine Class III studies included were retrospective cephalometric comparative studies (Table 2). Despite a wide bibliographic search, no perspective study or systematic review on this topic was found. Retrospective studies concerning treatment decisions for Class III borderline patients focused on three main aspects:

- Prognostic cephalometric parameters and predictive formulas (skeletal, dental, soft tissue)
- The influence of different biomechanics, such as extraction versus non-extraction orthodontic treatment plan to reach an ideal post-treatment condition
- Long-term follow-up and result stability

Prognostic Cephalometric Parameters and Predictive Formulas

In 1992, Kerr et al. [25] tried to determine some cephalometric benchmarks in adult patients with mild skeletal Class III malocclusions to find objective criteria for treatment options. They compared pre-treatment lateral cephalometric radiographs by using univariate statistical methods. Significant differences were found in the ANB Angle, maxillary–mandibular ratio, mandibular incisor inclination, and Holdaway Angle. They suggest that surgery should be performed when the ANB Angle is lower than $-4°$ and the IMPA lower than 83°. In view of the complex interaction of skeletal and dento-alveolar parameters, recent studies recommended a multivariate approach to analyzing the relationship between cranio-facial structure and Class III malocclusion [26], whereas this study does not include sagittal measurements nor individual soft-tissue variations.

In 2002, Stellzig Eisenhauer et al. [15], developed a formula based on a Discriminant Analysis (DA), to classify borderline Class III adults into two groups: one treatable by orthodontics-only and the other requiring orthognathic surgery. A DA is a multivariate procedure specifically designed to differentiate between two groups of subjects from the same population, using prediction models and criteria. The predictive model included many variables, but the Wits Appraisal Index turned out to be the most predictive variable. However, the DA has its limitations because a large sample size is a prerequisite to establish a sufficiently predictable model, and the selection of parameters might not include all variables required to accurately differentiate the groups. The DA could correctly allocate 97.7% of Class III patients who were treated with an orthodontic-only approach; however, 13.6% of those who needed surgery were misclassified. These findings led to the hypothesis that additional factors may be determining for the necessity of surgical intervention, such as transverse variables.

In 2011, Janka Kochel et al. [27] introduced their upgraded model by adding a new transverse parameter: a lower midline deviation greater than 3 mm. The four variables of the new formula where the Wits Appraisal Index, Mandibular/Maxilla Ratio, Saddle Angle, and Lower Midline Deviation (LMD). Despite this, the success rate of this improved equation was only 91.2%; therefore, the authors suggest using both formulas to determine which would be the best treatment for each patient. Furthermore, they emphasize the fact that the equation is a statistical model, so it may not fit every patient nor every ethnicity. Both Kochel's and Stellzig Eisenhauer's equations are used to calculate a critical score: if the patient's score is higher than the critical score, they can be successfully treated with an orthodontic-only camouflage.

In 2008, Rabie et al. [26] conducted a cephalometric retrospective study, selecting skeletal Class III with an ANB Angle greater than $-5^\circ$, treated with an extractive orthodontic-only approach or the combined orthodontic–surgical approach. Authors used a stepwise DA through which the Holdaway Angle proved to be the most reliable parameter: patients with a Holdaway Angle inferior to 12° would require surgical treatment. With the described approach, 72% of the sample were correctly classified in the pre-treatment stage. Interestingly, no difference was found in post-treatment soft-tissue measurements between the two groups and both treatments resulted in a satisfactory profile improvement. However, this study had various major limits, including a small sample size, a camouflage group that was limited to extraction cases, and the fact that different surgical procedures performed within the surgical group were not considered as a variable.

In 2011, Benyahia et al. [28] performed a similar cephalometric retrospective study. They improved the study design by adopting a larger sample size, adding an ethnic heterogeneity, and more selective recruitment criteria which gave priority to variables related to facial appearance, as well as to dento-alveolar and skeletal compensation. Post-treatment, all patients showed a three-dimensionally stable occlusion, a correct OVJ, and self-reported satisfactory facial esthetics. They found that the most predictive cephalometric value was the Holdaway Angle, with a threshold value of 7.2°; subjects with a Holdaway Angle greater than 7.2° could be successfully treated with no need for orthognathic surgery.

In 2017, Martinez et al. [16] performed a cross-sectional observational study to compare the variation of cephalometric parameters in adult patients with skeletal Class III malocclusions, treated with orthodontic camouflage (77), and with the combined orthodontic–surgical approach (79 patients, of which 30 underwent maxillary advancement, 16 mandibular setback, and 33 bimaxillary surgery). Statistically significant differences were found between the two groups for the Wits Appraisal Index, the lower incisor inclination, and the inter-incisal angle ($p < 0.05$); the Wits Appraisal was identified as being an ideal parameter to determine the need for surgical treatment. In conclusion, in those patients who had undergone orthognathic surgery, an incomplete lower incisor decompensation resulted in an incomplete surgical correction of the jaws; a result that is reported in several other studies. A strong correlation was found between initial and final values, indicating that the treatment behaved in a remarkably equivalent way for all patients. For variables corresponding to antero–posterior skeletal analysis, the correlation was much greater in cases treated by orthodontics-only camouflage. Surgery produced changes in values that were more dependent on the treatment itself, rather than on the pre-treatment values.

Lastly, in 2018, Eslami et al. [17] carried out a retrospective comparative study to delineate which cephalometric diagnostic measurements in adult borderline skeletal Class III cases (ANB of 0° to −4.5°; −8.5 < Wits Appraisal < −1 m) could determine the proper treatment modality. Treatment success was assessed by selecting patients (treated by camouflage or surgery) that were satisfied with the final esthetics. Results obtained by DA showed that the Holdaway Angle was the decisive parameter: the threshold value for the Holdaway Angle was 10.3° and it was −5.8 mm for the Wits Appraisal Index. The Holdaway Angle quantifies the protrusion of the upper lip relative to soft tissue profile and it does not vary according to the skeletal discrepancy; it is, therefore, the perfect parameter for characterizing the profile of borderline surgical skeletal Class III, in whom esthetics and facial appearance might be of greater importance than occlusion or skeletal discrepancy. These values had a treatment prediction value of 81.5%.

The Influence of Different Biomechanics: Extraction versus Non-Extraction Treatment Plan to Reach Ideal Post-Treatment Condition

In 2009, Troy et al. [29] performed a retrospective cephalometric study aiming to find a significant correlation between incisor inclination and position, and orthodontics-only or orthodontic-surgical treatment of skeletal Class III malocclusion. The camouflage group treatment, built on the already-existing dental compensations, resulted in non-skeletal changes as expected. Post-treatment, the surgical movements improved 90% of the skeletal discrepancies, but only 60 to 65% of the patients reached the ideal value, implying that there were no statistically significant differences between the two study groups. The authors suggest that surgical skeletal correction was compromised by an incomplete presurgical incisor decompensation.

In their 2015 case-control study, Georgalis et al. [18] aimed to analyze skeletal, dental, and soft tissue cephalometric changes occurring as a result of treatment, with emphasis on the influence of premolar extractions in the final incisor position and inclination.

Although skeletal, dental, and soft tissue discrepancies were comparable, it was found that a negative OVJ was a key factor in choosing between orthodontic camouflage and orthognathic surgery treatment. As expected, skeletal parameter normalization was only visible in the surgery group, but slightly protruded upper incisors were found in both surgery and camouflage groups at the end of treatment. In the camouflage group, lower premolar extraction did not result in a reduction in lingual tipping of lower incisors. While there was a general improvement in lip soft tissue position and contours with both treatment methods, a wide range of individual variation is probable, due to individual characteristics. At the end of treatment, surgery patients are more likely to have fuller lips, and a more favorable lower lip and chin contour than camouflage patients.

Long-Term Follow-Up and Result Stability

The only study including a long-term follow-up for skeletal Class III malocclusion treatment that we managed to find in our literature search, was a 2013 study by Xiong et al. [19]. They retrospectively compared results stability and esthetic satisfaction between a group of subjects treated with orthodontic camouflage (25 females) and a group treated with orthognathic bimaxillary surgery (21 females). Cephalometric data were recorded and compared at baseline (T1), at the end of treatment (T2), and three years post-treatment (T3). Patients completed questionnaires about their satisfaction and current problems, regarding teeth and profile, temporomandibular joint (TMJ), and functionality. Cephalometric data in both groups showed a satisfactory stability over the mid-term (3-year follow up). It is interesting that the percentage of patients who were satisfied with their profile changes was higher in the camouflage treatment than in the surgery group. Different expectations about profile changes were a key factor in determining esthetic patient satisfaction. It was observed that the camouflage group had little expectations, whereas profile and soft tissue changes were the main motivations for a surgical decision. Even if at baseline no TMJ disorder was elicited in this study, most of the surgical patients reported some form of functional and/or TMJ problems following their surgery, while the orthodontic group rarely had these issues, perhaps because during jaw surgery the proximal segment (which includes the condyle) can move backward, exerting stress on the articular surfaces and disc of the TMJ complex. Despite treatment differences, both modalities largely met their treatment objective. Therefore, if patients do not readily accept surgery because of potential surgical complications or financial difficulties, camouflage treatment could be an effective and stable alternative treatment. The major limit of this study was the short follow-up, as it has been shown that a 5-year follow up is the minimum period to verify stability of surgical treatment [30].

## 4. Discussion

It was the main scope of this narrative review to assess the quality of the available information on the treatment strategies and indications to treatment in Skeletal Class II and Class III adult borderline patients.

At the present time, poor-quality data and incomplete information are available on the "best practice regime" that should be adopted in adult skeletal borderline patients.

The small and non-homogeneous sample sizes, lack of sample size estimation, absence of similar comparison groups at the pre-treatment stage, and the variability or absence of follow-up data were some of the main shortcomings.

As we expected, surgical treatment was found to better improve cephalometric skeletal values, whereas camouflage treatment resulted primarily in dento-alveolar movements both in Class II and Class III cases. Extraction treatments (both in camouflage and combined surgical treatment) were not necessarily associated with ideal values for incisor position and inclination, especially with regard to Class III borderline cases. Contrarily, clinical expertise and adoption of specific biomechanics are key factors for a successful treatment [10,18,29].

All studies lacked an appropriate analysis of the facial soft tissue, limiting their evaluation to sagittal cephalometric changes. Since there is wide inter-individual soft tissue variation, the use of complete 3D soft-tissue evaluation is necessary, including analysis of facial shapes and volumes, and of the soft tissue biotype and thickness, which would result in a more robust Discriminant Analysis of treatment results.

Self-perceived esthetics after camouflage and surgical treatment do not seem to be significantly different, although recent improvements in surgical techniques may provide enhancement in surgical treatment outcomes. Most of the reviewed studies present outdated clinical data, primarily planned on 2D analysis, both for the surgical and for the orthodontic clinical settings. It is plausible that a new data comparison between a borderline surgical pool and comparable camouflage patients, based on a 3D quantitative and qualitative assessment, would add new insights. Several cephalometric variables are suggested to be clinically useful, such as the Wits appraisal for sagittal discrepancy, which is preferable to the SNB-angle because it relates the maxilla and mandible to the occlusal plane, independently by the craniofacial reference. Thus, any jaw rotation relative to the cranial reference plane does not affect the severity of the jaw disharmony [14,17,26,28]. Skeletal convexity (N-A-Pg) and soft tissue convexity including the nose (N0-Pn-PogO) and excluding the nose (NO-Sn-PogO), should also be considered [14]. Orthognathic surgery is preferred when there is an OVJ >10 mm, a mandibular length <70 mm, Pg-Na of approximately 18 mm, and a facial height >125 mm [2]. The true vertical sub-nasal line should be adopted for soft-tissue profile evaluation because it is independent of the position of chin and nose, thus being preferable to the E-line. In borderline skeletal Class III malocclusions, the Holdaway Angle and Wits Appraisal seem to be the main cephalometric parameters to discriminate between camouflage orthodontic treatment or orthognathic surgical treatment [17,26,28]. However, a disparity in threshold values exists among studies, and it is probably due to different sample sizes, ethnicities, and selective parameters at baseline. Further [16], it has been suggested that the combination of the Wits Appraisal, lower incisor inclination, and inter-incisal angle are indicative of treatment selection.

From the present review, it emerged that self-image perception and potential esthetic improvement should be considered as the most important parameters in treatment decisions. However, esthetic assessment tends to be poorly structured, with differences in perception between surgeons, orthodontists, and lay-people. Dental and facial esthetic, self-image, and self-esteem, are major motivating factors for those seeking surgical treatment and will be likely to determine a patient's selection of a treatment option [31]. Whereas morphometric analysis is a poor indicator of a patient's treatment needs and expectations, psychological assessment before treatment could help as a discriminant parameter in treatment selection [32,33]. Patients who reported improvements in self-confidence, self-concept, and social interactions after treatment, showed higher levels of satisfaction with outcomes. Furthermore, there is strong evidence that the resolution of malocclusion relates with self-impairment, improved quality of life, and emotional and social status [9].

The present narrative review presents several limits that we would like to point out. Neither transversal skeletal discrepancies nor asymmetries were included in the present review. Sagittal skeletal discrepancy both in Class II and Class III conditions is influenced by, and related to, transversal correction; these would add further information to the assessment of the treatment decision issue concerning borderline cases. In addition, the presence and the tridimensional evaluation of any asymmetry, dental versus skeletal and skeletal versus facial soft tissue, could orient the clinician to the best and most stable treatment strategy.

Because of incomplete data, it was not possible to evaluate how different adopted surgical procedures would lead to different aesthetic outcome in a similar pool of patients defined "borderline".

We did not evaluate the presence of possible functional problems such as OSAS conditions and respiratory deficiency, in which the degree of the severity, even in skeletal borderline patients, could redirect to a specific treatment approach. The OSAS issue could have been an interesting point of discussion when speaking of parameters that bring the clinician to opt for one treatment or another. This said, it is important to underline that a patient suffering from OSAS, even in presence of skeletal "borderline" anthropometric characteristics, would be treated following OSAS guidelines and not orthognathic–orthodontic criteria, in order to resolve their health issues [34–36].

Finally, we did not evaluate the periodontal biotype and thickness which is an important issue, particularly in adult patients in whom the intraoral soft-tissue envelope conditions, most of the time, the sequence and the treatment of choice.

## 5. Conclusions

From the present review, it emerged that the decision-making process in skeletal adult borderline patients still stands within the clinician's expertise and background. No strong recommendations based on a robust evidence-based approach have yet been proposed. Self-image perception and potential aesthetic improvement are to be considered as the most important parameters in treatment decision. Psychological assessment before treatment could help as a discriminant parameter in treatment selection. A tridimensional skeletal and soft tissue appraisal is recommended to evaluate the most efficient therapy in the short and long term. Further studies, with larger sample sizes, similar pretreatment conditions and pretreatment personality traits, and patient self-evaluations of esthetics and function, should be carried out.

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