



## Major considerations of ortho-surgical procedures in Class III patients: a systematic review

Daniely Cristina Moreale<sup>1\*</sup>, Caroline Gabriele Vieira<sup>1</sup>, Richard de Oliveira Bottcher<sup>1</sup>, Elias Naim Kassir<sup>1,2</sup>

<sup>1</sup> UNORTE - University Center of Northern São Paulo - Dentistry department, Sao Jose do Rio Preto, Sao Paulo, Brazil.

<sup>2</sup> UNIPOS - Post graduate and continuing education, Dentistry department, Sao Jose do Rio Preto, Sao Paulo, Brazil.

\*Corresponding author: Dr. UNORTE/UNIPOS - Graduate and Postgraduate in Dentistry, Sao Jose do Rio Preto, Sao Paulo, Brazil.

E-mail: danii.moreale@hotmail.com

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### Abstract

**Introduction:** In the setting of ortho-surgical procedure, malocclusion has a prevalence of about 6% in children in Brazil. Orthodontics excels in repair and cosmetic surgery. Most cases of Class III malocclusion have maxillary retrusion or hypoplasia, which may or may not be associated with mandibular prognathism.

**Objective:** It was performed a systematic review to list the main considerations and clinical findings of ortho-surgical surgery in class III patients. **Methods:** The present study followed a systematic review model, following the rules of systematic review – PRISMA. The search strategy was performed in the PubMed, Cochrane Library, Web of Science and Scopus, and Google Scholar databases. The present study was carried out from February to May 2022. The quality of the studies was based on the GRADE instrument, with randomized controlled clinical studies, prospective controlled clinical studies, and studies of systematic review and meta-analysis listed as the studies with the greatest scientific evidence, and the risk of bias was analyzed according to the Cochrane instrument. Initially, 289 articles were found and, after selection, 54 articles were used to compose the present study. **Results and**

**Conclusion:** According to the objective of this study, the Class III treatment should be related to the diagnosis to correct the compromised structures, not done in places not affected by the malocclusion. Still, the degree of involvement of the maxilla and mandible must be evaluated so that the treatment is directed to that bone base for facial improvement. The displacement processes that occur in the midface can only be affected with treatment as long as the growth zones can respond to the biomechanical stimulus.

Therefore, the younger the Class III patient is treated, the better the facial correction effects will be.

**Keywords:** Ortho-surgical. Malocclusion. Mandibular prognathism. Class III patients.

### Introduction

In the scenario of ortho-surgical procedure, malocclusion has a prevalence of about 6% in children in Brazil [1]. Boys are more prone to dental trauma than girls. Furthermore, Class III malocclusion can affect about 15% of the Brazilian population [1]. In this sense, orthodontics stands out in repair and aesthetic surgery [2,3]. Still in this context, it is suggested that most cases of Class III malocclusion have maxillary retrusion or hypoplasia, which may or may not be associated with mandibular prognathism [4,5].

Thus, the treatment of Class III malocclusion before the late mixed dentition appears to induce more favorable craniofacial changes, with a significant increase in maxillary sagittal growth. However, a mandibular restriction effect can be achieved in a later treatment [6-8]. The use of a face mask at a young age, even without palatal expansion, is effective for the correction of skeletal Class III. Therefore, expansion should be indicated based on the clinical characteristics of the case [9]. The harmonic functional aspect of the patient is important for the stability of the results. The dental and skeletal modifications of the Class III correction produce an improvement in the relationship between the teeth, the bony bases, and the soft tissues [9].

In this context, several treatment modalities are proposed for the correction of Class III malocclusion [10]. Approaches include the use of a protraction face

mask with rapid maxillary expansion, face mask without maxillary expansion, face mask with alternating maxillary expansion and constriction, face mask associated with mini-implants in the zygomatic pillar, use of mini-implants orthodontic appliances in the lower arch as an anchor for maxillary traction using a removable upper appliance, use of mini-implants in the retromolar region, use of mini-implants by buccal of the lower arch, posterior region, use of chin cup, reverse chin cup, functional Fränkel regulatory appliance use of acrylic grid and stop, use of removable mandibular retractor, use of reverse “twin block”, and use of “tandem traction bow appliance” [11-15].

In this scenario, it is of paramount importance that the diagnosis is made as early as possible since skeletal discrepancies are quite difficult to correct due to the complexity of the treatment and the lack of predictability in the growth pattern of patients [20,21]. It is well documented in the literature that, in patients with Class III malocclusion still with growth potential, the most used treatment protocol is the protraction face mask associated with rapid maxillary expansion [18-20].

Therefore, the present study carried out a systematic review to list the main considerations and clinical findings of ortho-surgical procedure in class III patients.

**Methods**

**Study Design**

The present study followed a systematic review model, following the rules of systematic review - PRISMA (Transparent reporting of systematic review and meta-analysis, access available in: <http://www.prisma-statement.org/>).

**Data Sources**

The search strategy was performed in the PubMed, Cochrane Library, Web of Science and Scopus, and Google Scholar databases. The present study was carried out from February to May of 2022.

**Descriptors (MeSH Terms) And Search Strategy**

The main descriptors (MeSH Terms) used were “Ortho-surgical. Malocclusion. Mandibular prognathism. Class III patients”. The rules of the word PICOS (Patient; Intervention; Control; Outcomes; Study Design) were followed.

**Selection Process, Risk of Bias and Quality of Studies**

Two independent reviewers performed research and study selection. Data extraction was performed by

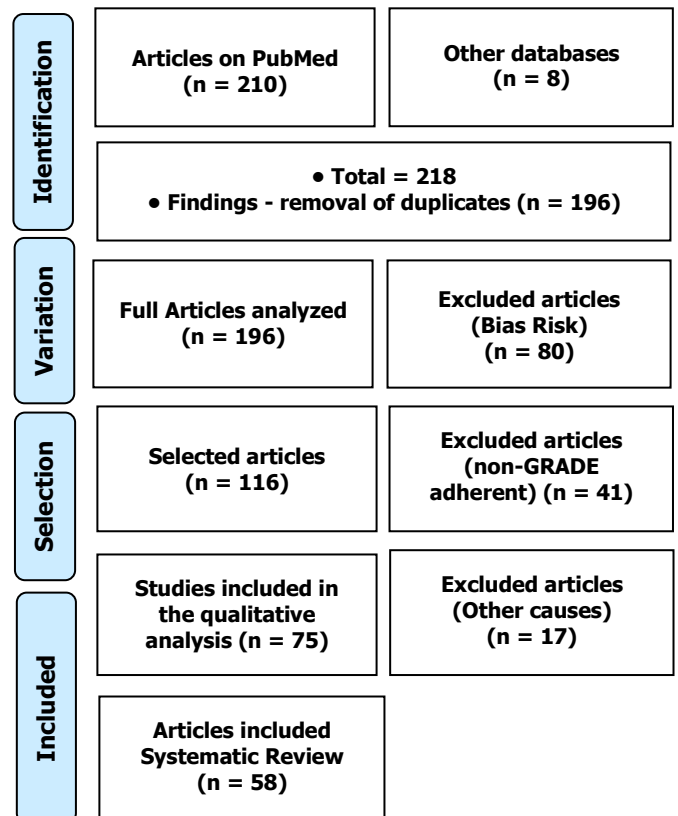
reviewer 1 and fully reviewed by reviewer 2. A third investigator decided some conflicting points and made the final decision to choose the articles. The quality of the studies was based on the GRADE instrument, with randomized controlled clinical studies, prospective controlled clinical studies, and studies of systematic review and meta-analysis listed as the studies with the greatest scientific evidence, and the risk of bias was analyzed according to the Cochrane instrument.

**Results and Discussion**

**Summary of Literary Findings**

A total of 218 articles were found. Initially, duplicate articles were excluded. After this process, the abstracts were evaluated and a new exclusion was performed based on the GRADE Instrument and Risk of Bias. A total of 75 articles were fully evaluated and 58 were included and discussed in this study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 80 studies that were excluded with a high risk of bias (studies with small sample size). Also, 41 studies were excluded because they did not meet the GRADE (Figure 1).

**Figure 1.** Flowchart showing the article selection process.



**Major Findings**

Based on the main findings, it was observed that the two most frequent problems in Class III treatment

are the time of treatment and the type of appliance [22]. Various appliances have been used to correct a Class III skeletal discrepancy, but little evidence is available on their long-term effectiveness. Likewise, early treatment of Class III malocclusion has been practiced with increasing interest. However, there is no solid evidence of long-term benefits [22,23].

Thus, a meta-analysis study evaluated the effectiveness of orthodontic/orthopedic methods used in the early treatment of Class III malocclusion in the short and long term. Fifteen studies, 9 RCTs, and 6 CCTs were included in this review. In the RCT group, only 3 of the 9 studies were assessed at low risk of bias, and the others were at high or unclear risk of bias. All 6 CCT studies were classified as high risk of bias. Three randomized controlled trials involving 141 participants analyzed the comparison between protraction masks and untreated control. The results for reverse overjet (mean difference, 2.5 mm; 95% CI, 1.21-3.79;  $P = 0.0001$ ) and ANB angle (mean difference, 3.90°; 95% CI, 3, 54-4.25;  $p < 0.0001$ ) were statistically significant in the face mask group. All CCTs demonstrated a statistically significant benefit in favor of using each device. However, the studies had a high risk of bias. Therefore, there is a moderate amount of evidence to show that early treatment with a face mask results in improvement for short-term skeletal and dental effects. However, there was a lack of evidence on long-term benefits [24].

Also, Mandall et al. [21] tested the Class III treatment with the face mask associated with rapid maxillary expansion and concluded that it was effective both skeletally and dentally. The only difference in the respective studies was the follow-up time after achieving a Class I molar relationship, which ranged from 15 months to 36 months. Maxillary expansion before face mask treatment is used in most cases because it has the benefits of correcting the posterior crossbite when present, increasing the length of the arch, opening the bite, generating loosening/activation of the circumaxillary sutures, and generating an initiation of downward and forward movement of the maxillary complex [25-29]. However, Vaughn et al. [30], in a randomized clinical trial, testing maxillary protraction in a group with expansion and another without previous maxillary expansion, concluded that the changes produced to the dentofacial complex were equivalent to an improvement in Class III malocclusion, in addition to there is no change in the total treatment time. Maxillary expansion is only necessary in cases of posterior crossbite or space deficiency [31-42].

These results are also in agreement with the systematic review conducted by Kim et al. [43]. In contrast to the use or not of maxillary expansion before

maxillary protraction treatment, Liu et al. [40] tested the expansion plus constriction protocol and observed that there were some statistically significant differences, such as better anterior movement of the maxilla and rotation of the mandibular and palatal planes in the expansion/constriction group, but these changes did not demonstrate any clinical relevance.

Besides, chin cups have been used for the control of mandibular protrusion in growing patients for almost a century [44]. However, a deeper investigation of the literature revealed controversies and contradictions regarding the methodology of use, such as the appropriate age for starting treatment and the magnitude of force used. The clinical effectiveness is much debated by authors who use different protocols, obtaining different results [45-48].

Furthermore, Abdelnaby and Nassar [34] performed a study on patients aged between nine and ten years with chin cups with occipital pull using two magnitudes of force. The authors obtained as results a significant decrease in the SNB angle both by the clockwise rotation of the mandible and by the increase in the anterior facial height in the two treated groups when compared to the untreated, data which are also in agreement with the systematic review elaborated by Chatzoudi et al. [49]. The results achieved with the use of this device significantly improved the maxillomandibular relationship, however, with few skeletal effects, the difference in force magnitude generated the same effects.

Faced with so many devices already used and tested for the treatment of Class III malocclusion, because they are not very aesthetic, several authors seek to develop new devices that can facilitate use and, consequently, patient acceptance. Showkatbakhsh et al. [33] developed a new device called the reverse chin cup, to make a maxillary protraction. In this randomized clinical trial, the age range of patients ranged from seven to ten years, and aimed to compare their effectiveness with the face mask. In both treatments, an anterior movement of the maxilla was achieved, as well as a proclination of the anterior maxillary teeth and a lingualization of the mandibular incisors. The authors mention that, as the face mask is of a bulky size, children feel discouraged from using it, especially at school, due to shame and the discomfort it generates. Thus, they suggest that the use of the reverse chin cup, as it is a more aesthetically acceptable method, maybe a better option for maxillary protraction.

The use of the lingual grid or the removable upper acrylic stop generates a pressure of the tongue on the shield, causing this force to be transmitted to the maxilla, causing its movement to the anterior [50,51]. When comparing its effects with that of the face mask,

the results are similar in moving the maxilla forward. An advantage is that the lingual cradle does not cause some unfavorable effects on the mandible (backward and downward rotation) for patients with a vertical growth pattern [51,52].

Finally, it is known that treatments with skeletal anchorage are becoming a new paradigm for the early treatment of Class III malocclusion [53-54]. Several studies cite the use of extraoral apparatus associated with this type of anchorage [56,57]. The use of mini-implants placed bilaterally in the zygomatic pillar associated with a face mask or placed between the roots of the canines and lower first premolars labially associated with a removable upper appliance 28 with Class III hooks and elastics can be used to traction the jaw forward. Such treatment modalities, when compared with the use of a face mask, present similar results in the correction of the maxillary deficiency. The fact of using devices of smaller size, causing a smaller aesthetic imbalance, can generate a better acceptance of the patient, making the treatment can be started earlier [58].

## Conclusion

According to the objective of this study, the treatment of Class III should be related to the diagnosis to correct the compromised structures, not done in places not affected by the malocclusion. Still, the degree of involvement of the maxilla and mandible must be evaluated so that the treatment is directed to that bone base for facial improvement. The displacement processes that occur in the midface can only be affected with treatment as long as the growth zones can respond to the biomechanical stimulus. Therefore, the younger the Class III patient is treated, the better the facial correction effects will be.

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## Informed consent

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## Data sharing statement

No additional data are available.

## Conflict of interest

The authors declare no conflict of interest.

## Similarity check

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## References

1. Doriguêto PVT, Carrada CF, Scalioni FAR, et al. Malocclusion in children and adolescents with Down syndrome: A systematic review and meta-analysis. *Int J Paediatr Dent*. 2019;29(4):524-541. doi:10.1111/ipd.12491.
2. Duarte V, Zaror C, Villanueva J, Andreo M, Dallaserra M, Salazar J, Pont À, Ferrer M. Oral Health-Related Quality of Life Changes in Patients with Dentofacial Deformities Class II and III after Orthognathic Surgery: A Systematic Review and Meta-Analysis. *Int J Environ Res Public Health*. 2022 Feb 9;19(4):1940. doi: 10.3390/ijerph19041940. PMID: 35206128; PMCID: PMC8872566.
3. Reis GM, de Freitas DS, Oliveira RC, de Oliveira RCG, Pinzan-Vercelino CRM, Freitas KMS, Valarelli FP. Smile attractiveness in class III patients after orthodontic camouflage or orthognathic surgery. *Clin Oral Investig*. 2021 Dec;25(12):6791-6797. doi: 10.1007/s00784-021-03966-w. Epub 2021 May 6. PMID: 33959816.
4. Dos Santos MC, Iwaki LCV, Valladares-Neto J, Inoue-Arai MS, Ramos AL. Impact of orthognathic surgery on the prevalence of dehiscence in Class II and Class III surgical-orthodontic patients. *Angle Orthod*. 2021 Sep 1;91(5):611-618. doi: 10.2319/062720-590.1. PMID: 33836070; PMCID: PMC8376160.
5. Noh HK, Park HS. Does maxillary yaw exist in patients with skeletal Class III facial asymmetry? *Am J Orthod Dentofacial Orthop*. 2021 Oct;160(4):573-587. doi: 10.1016/j.ajodo.2020.05.025. Epub 2021 Jul 29. PMID: 34332794.
6. Watkinson S, Harrison JE, Furness S, Worthington HV. Orthodontic treatment for prominent lower front teeth (Class III malocclusion) in children. *Cochrane Database Syst Rev* 2013; (9):CD003451.
7. Seehra J, Fleming PS, Mandall N, Dibiase AT. A



- comparison of two different techniques for early correction of Class III malocclusion. *Angle Orthod* 2012;82:96-101.
8. Liu ZP, Li CJ, Hu HK, Chen JW, Li F, Zou SJ. Efficacy of short-term chin cup therapy for mandibular growth retardation in Class III malocclusion. *Angle Orthod* 2011;81:162-8.
  9. Kurt H, Alioglu C, Karayazgan B, Tuncer N, Kilicoglu H. The effects of two methods of Class III malocclusion treatment on temporomandibular disorders. *Eur J Orthod* 2011;33:636-41.
  10. Saleh M, Hajeer MY, Al-Jundi A. Assessment of pain and discomfort during early orthodontic treatment of skeletal Class III malocclusion using the Removable Mandibular Retractor Appliance. *Eur J Paediatr Dent* 2013;14:119-24.
  11. Angle EH. Classification of malocclusion. *Dent. Cosmos*. 1899;41:248-64.
  12. Sanborn RT. Differences between the facial skeletal patterns of Class III malocclusion and normal occlusion. *Angle Orthod*. 1955;25:208-22.
  13. Guyer EC, Ellis EE, McNamara JA, Behrents RG. Components of Class III malocclusion in juveniles and adolescents. *Angle Orthod*. 1986;56:7-30.
  14. Ellis E 3rd, McNamara JA Jr. Components of adult Class III open-bite malocclusion. *Am J Orthod*. 1984;86:277-90.
  15. Showkatbakhsh R, Jamilian A, Behnaz M, Ghassemi M, Ghassemi A. The short-term effects of Face mask and Fixed Tongue Appliance on Maxillary Deficiency in Growing Patients – A Randomized Clinical Trial. *Int J Orthod*. 2015;26(1)29-34.
  16. Proffit WR. *Contemporary Orthodontics*. 4th ed. St Louis: CV Mosby; 2007.
  17. Haynes S. The prevalence of malocclusion in English children aged 11–12 years. *Rep Congr Eur Orthod Soc*. 1970:89-98.
  18. Cobourne M. Early treatment for class III malocclusion. *J Orthod*. 2016;43(3):159-160. doi:10.1080/14653125.2016.1215860.
  19. Agostino P, Ugolini A, Signori A, Silvestrini-Biavati A, Harrison JE, Riley P. 2014. Orthodontic treatment for posterior crossbites. *Cochrane Database Syst Rev*. 8: CD000979.
  20. Mandall N, Cousley R, DiBiase A, Dyer F, Littlewood S, Mattick R, et al. 2016. Early class III protraction facemask treatment reduces the need for orthognathic surgery. A multicentre, two-arm parallel randomised, controlled trial. *J Orthod*. 43: 164–175.
  21. Mandall N, DiBiase A, Littlewood S, Nute S, Stivaros N, McDowall R, et al. 2010. Is early class III protraction facemask treatment effective? A multicentre, randomised, controlled trial: 15-month follow-up. *J Orthod*. 37: 149–161.
  22. Thiruvenkatachari B, Harrison JE, Worthington HV, O'Brien KD. 2013. Orthodontic treatment for prominent upper front teeth (Class II malocclusion) in children. *Cochrane Database Syst Rev*. 11: CD003452.
  23. Irie M, Nakamura S. Orthopedic approach to severe skeletal Class III malocclusion. *Am J Orthod*. 1975;67:377-92.
  24. Woon SC, Thiruvenkatachari B. Early orthodontic treatment for Class III malocclusion: A systematic review and meta-analysis. *Am J Orthod Dentofacial Orthop*. 2017;151(1):28-52. doi:10.1016/j.ajodo.2016.07.017].
  25. Baik HS, Han HK, Kim DJ, Proffit WR. Cephalometric characteristics of Korean Class III surgical patients and their relationship to plans for surgical treatment. *Int J Adult Orthodon Orthognath Surg*. 2000;15:119-28.
  26. Chan GK. Class III malocclusion in Chinese: etiology and treatment. *Am J Orthod*. 1974;65:152–56.
  27. De Toffol L, Pavoni C, Baccetti T, Franchi L, Cozza P. Orthopedic Treatment Outcomes in Class III Malocclusion A Systematic Review. *Angle Orthod*. 2008;78:561-73.
  28. Turchetta BJ, Fishman LS, Subtelny JD. Facial growth prediction: a comparison of methodologies. *Am J Orthod Dentofacial Orthop*. 2007; 132:439-49.
  29. Yoshida I, Yamaguchi N, Mizoguchi I. Prediction of post-treatment outcome after combined treatment with maxillary protraction and chin cup appliances. *Eur J Orthod*. 2006;28:89-96.
  30. Vaughn GA, Mason B, Moon HB, Turley PK. The effects of maxillary protraction therapy with or without rapid palatal expansion: A prospective, randomized clinical trial. *Am J Orthod Dentofacial Orthop*. 2005;128:299-309.
  31. Ge YS, Liu J, Chen L, Han JL, Guo X. Dentofacial effects of two facemask therapies for maxillary protraction: Miniscrew implants versus rapid maxillary expanders. *Angle Orthod*. 2012;82:1083-91.
  32. Jamilian A, Haraji A, Showkatbakhsh R, Valaee N. The Effects of Miniscrew with Class III Traction in Growing Patients with Maxillary Deficiency. *Int Journal Orthod*. 2011;22:25-30.
  33. Showkatbakhsh R, Jamilian A, Ghassemi M, Ghassemi A, Taban T, Imani Z. The Effects of facemask and reverse chin cup on maxillary deficient patients. *Journal of Orthod*. 2012;39:95-

- 101.
- 34.** Abdelnaby YL, Nassar EA. Chin cup effects using two different force magnitudes in the management of Class III malocclusions. *Angle Orthod.* 2010;80:957-62.
- 35.** Showkatbakhsh R, Toumarián L, Jamilian A, Sheibaninia A, Mirkarimi M, Taban T. The effects of facemask and tongue plate on maxillary deficiency in growing patients: a randomized clinical trial. *Journal of Orthod.* 2013;40:130-36.
- 36.** Ülgen M, Firatli S. The effects of Fränkel's function regulator on the class III malocclusion. *Am J Orthod Dentofacial Orthop.* 1994;105:561-67.
- 37.** Atalay Z, Tortop T. Dentofacial effects of a modified tandem traction bow appliance. *Eur J Orthod.* 2010;32:655-61.
- 38.** Arman A, Toygar, TU, Abuhijleh, E. Evaluation of maxillary protraction and fixed appliance therapy in Class III patients. *Eur J Orthod.* 2006;28:383-92.
- 39.** Mandal NA, Cousley R, DiBiase A, Dyer F, Littlewood S, Mattick R. et al. Is early class III protraction facemask treatment effective? A multicentre, randomized, controlled trial: 3-year follow-up. *Journal of Orthod.* 2012;39:176-85.
- 40.** Liu W, Zhou Y, Wang X, Liu D, Zhou S. Effect of maxillary protraction with alternating rapid palatal expansion and constriction vs expansion alone in maxillary retrusive patients: A single-center, randomized controlled trial. *Am J Orthod Dentofacial Orthop.* 2015;148:641-51.
- 41.** Showkatbakhsh R, Jamilian A, Taban T, Golrokh M. The effects of Face mask and Tongue Appliance on Maxillary Deficiency in growing patients: A randomized clinical trial. *Progress in orthodontics.* 2012;13:266-72.
- 42.** Seehra J, Fleming PS, Mandall N, DiBiase AT. A comparison of two different techniques for early correction of Class III malocclusion. *Angle Orthod.* 2012;82:96-101.
- 43.** Kim JH, Viana MAG, Graber TM, Omerza FF, BeGole EA. The effectiveness of protraction facemask therapy: A meta-analysis. *Am J Orthod Dentofac Orthop.* 1999;115:675-85.
- 44.** Watkinson S, Harrison JE, Furness S, Worthington HV. Orthodontic treatment for prominent lower front teeth (Class III malocclusion) in children. *Cochrane Database of Systematic Reviews* 2013, Issue 9.
- 45.** Cordasco G, Matarese G, Rustico L, Fastuca S, Caprioglio A, Lindauer SJ et al. Efficacy of orthopedic treatment with protraction facemask on skeletal Class III malocclusion: a systematic review and meta-analysis. *Orthod Craniofac Res.* 2014;17:133-43.
- 46.** Foersch M, Jacobs C, Wriedt S, Hechtner M, Wehrbein H. Effectiveness of maxillary protraction using facemask with or without maxillary expansion: a systematic review and meta-analysis. *Clin Oral Invest.* 2015;19:1181-92.
- 47.** Morales-Fernández M, Iglesias-Linares A, Yañez-Vico RM, MendozaMendoza A, Solano-Reina E. Bone- and dentoalveolar-anchored dentofacial orthopedics for Class III malocclusion: New approaches, similar objectives? A systematic review. *Angle Orthod.* 2013;83:540-52.
- 48.** Ye C, Zhihe Z, Zhao Q, Ye J. Treatment Effects of Distal Movement of Lower Arch With Miniscrews in the Retromolar Area Compared With Miniscrews in the Posterior Area of the Maxillary. *J Craniofac Surg.* 2013;24:1974-79.
- 49.** Chatzoudi MI, Ioannidou-Marathiotou I, Papadopoulos MA. Clinical effectiveness of chin cup treatment for the management of Class III malocclusion in pre-pubertal patients: a systematic review and meta-analysis. *Progress in Orthodontics.* 2014;15:62.
- 50.** Yang X, Li C, Bai D, Su N, Chen T, Xu Y, et al. Treatment effectiveness of Fränkel function regulator on the Class III malocclusion: A systematic review and meta-analysis. *Am J Orthod Dentofacial Orthop.* 2014;146:143-54.
- 51.** Saleh M, Hajeer Y, Al-Jundi A. Short-term soft- and hard-tissue changes following Class III treatment using a removable mandibular retractor: a randomized controlled trial. *Orthod Craniofac Res.* 2013;16:75-86.
- 52.** Keim RG, Gottlieb EL, Nelson AH. Vogels DS 3rd. 2008 JCO study of orthodontic diagnosis and treatment procedures. Part 3: more breakdowns of selected variables. *J Clin Orthod.* 2009;43:22-33.
- 53.** McNamara JA JR, Brudon WL. *Orthodontics and dentofacial orthopedics.* Ann Arbor, Mich: Needham Press; 2001.
- 54.** Turley PK. Orthopedic correction of Class III malocclusion with palatal expansion and custom protraction headgear. *J Clin Orthod.* 1988;22:314-25.
- 55.** Tuncer BB, Kaygisiz E, Tuncer C, Yuksel S. Pharyngeal airway dimensions after chin cup treatment in Class III malocclusion subjects. *J Oral Rehab.* 2009;36:110-17.
- 56.** Liu C, Hou M, Liang L, Huang X, Zhang T, Zhang H, et al. Sutural distraction osteogenesis (SDO) versus osteotomy distraction osteogenesis (ODO) for midfacial advancement: A new technique and primary clinical report. *J Craniofac Surg.*

2005;16:537-48.

- 57.** Kircelli BH, Pektas ZO. Midfacial protraction with skeletally anchored face mask therapy: a novel approach and preliminary results. *Am J Orthod Dentofacial Orthop.* 2008;133:440-49.
- 58.** De Clerck HJ, Cornelis MA, Cevidanes LH, Heymann GC, Tulloch CJ. Orthopedic traction of the maxilla with mini- plates: a new perspective for treatment of midface deficiency. *J Oral Maxillofac Surg.* 2009;67:2123-29.