Occlusal Cant and Its Challenges – A Review

Renuka Rao Talla¹, Ranjit H. Kamble², Hamza Saifuddin Dargahwala³, Karthika Manoj Nambiar⁴, Vikrant V. Jadhav⁵

^{1, 2, 3, 4, 5} Department of Orthodontics and Dentofacial Orthopaedics, Sharad Pawar Dental College, Datta Meghe Institute of Medical Sciences, Sawangi, Wardha, Maharashtra, India.

ABSTRACT

Asymmetries can be considered as a huge challenge for an orthodontist because of the complex mechanics and uncertainty in stability of treatment outcomes. Multifactorial nature of the asymmetry due to wide range has complicated the classification and determination of the cases. The aetiology can be classified as hereditary and environmental factors. The occlusal cant in patients can be evaluated by frontal photographs, lateral cephalograms, clinical assessment and a three-dimensional imaging methods.

Photographs can be used as one of the methods to evaluate the asymmetries of the soft tissue and also the cant of lips. In recent times with the aid of computers and different software's like power point or keynote the use of reference lines with the software, facilitates in the analysis of the smile and the occlusal plane. The management of occlusal cant includes different treatment alternatives like orthognathic surgery, orthodontic therapy, or a combination treatment of both orthognathic surgery and orthodontic therapy.

The surgical approach depends upon the awareness of the patient with the severity of cant and aesthetic problems as well as the jaw discrepancy in both vertical and sagittal directions. Orthognathic surgery creates an overall skeletal as well as soft tissue improvement including the lips. In cases with OC in anterior segment and deep - bite malocclusion a combination treatment is required. To reduce the anterior vertical height and to achieve more stable results intrusion of molars is considered using skeletal anchorage.

The skeletal anchorage (miniscrews or miniplates) can be used for the correction of the cant in maxillary segment and the surgical treatment for correction of the asymmetry of the face like sagittal split osteotomy, ramus osteotomy etc. can be carried out. To achieve satisfactory outcome the clinician must examine and find the etiological factors and proper treatment planning has to be carried out based on the type of occlusal cant such that the outcome shows aesthetic smile along with good facial symmetry.

Corresponding Author:

*Dr. Renuka Talla,
Department of Orthodontics and
Dentofacial Orthopaedics, Sharad Pawar
Dental College and Hospital, Datta Meghe
Institute of Medical Sciences, Sawangi,
Wardha, India.
E-mail: renukat2795@gmail.com*

DOI: 10.14260/jemds/2021/577

How to Cite This Article:

*Talla RR, Kamble RH, Dargahwala HS, et al.
Occlusal cant and its challenges – a review.
J Evolution Med Dent Sci 2021;10(33):
2835-2840, DOI:
10.14260/jemds/2021/577*

*Submission 29-03-2021,
Peer Review 11-06-2021,
Acceptance 19-06-2021,
Published 16-08-2021.*

*Copyright © 2021 Renuka Rao Talla et al.
This is an open access article distributed
under Creative Commons Attribution
License [Attribution 4.0 International (CC
BY 4.0)]*

KEY WORDS

Occlusal Cant, Facial Asymmetry, Skeletal Asymmetry, Cant.

BACKGROUND

Balanced smile is one of the most important goals in orthodontics, which can be described as proper positioning of the teeth and gingival scaffold within the dynamic display zone¹ which is in turn affected by the size, shape, position, and colour of teeth and also depends on buccal corridor, contour of gingiva and framing of lips, upper and lower midline discrepancies.² Asymmetries can be considered as a huge challenge for an orthodontist because of the complex mechanics and uncertainty in stability of treatment outcomes. Cant in occlusal plane is one of the asymmetries which cause additional challenges in the treatment. Occlusal plane can be described as the line passing through one half of the cuspid heights of the first permanent molars and one half of the overbite of incisors.³

Occlusal Plane

Theoretically occlusal plane touches the incisal edges and the tips of posterior teeth at their occlusal surfaces. It represents a mean curvature of the occluding surface. The plane of occlusion of the dental arches is curved such that it permits maximum tooth contact during mastication which is also known as the "Curve of Spee".^{4,5,6,7} A curve which is associated with the occlusal plane and can be observed from frontal view is known as "Curve of Wilson".⁶ In cephalometrics occlusal plane can be referred to as the line bisecting the overlapping cusps of the first molars and incisor overbite whereas in Posteroanterior view it is the line joining the buccal cusps of right and left first molars in transverse direction. Rotation of the maxilla posteriorly as well as relocation of both the jaws maxilla and mandible in the vertical direction causes change in position of occlusal plane whereas, the inclination of occlusal plane is increased in a clockwise direction along with the growth.

Occlusal Cant

Occlusal cant can be described as changes in the longitudinal plane. The occlusal plane canting in vertical plane is one of the contributing factors in affecting smile esthetics⁸ and can originate from either facial asymmetry or asymmetry in vertical positioning of right and left quadrants of the dental arches without any facial asymmetry. Occlusal cant is frequently seen to be associated with facial asymmetry. The frequency has been recorded to be between 21 % and 80 %. This wide range is a result of different types of skeletal malocclusion, ethnicity and age. It may also be affected due to various methods, measurements, and sensitivity between studies.^{9,10-14}

Aetiologic Factors in Asymmetry and Occlusal Cant

Multifactorial nature of the asymmetry due to wide range has complicated the classification and determination of the cases. The aetiology can be classified as hereditary and environmental factors.¹⁵ The hereditary factors include cleft lip and palate,¹⁶ juvenile idiopathic arthritis, Albright syndrome,¹⁷ hemifacial macrosomia,¹⁸ Treacher Collins syndrome, Crouzon syndrome, Apert syndrome and

craniosynostosis.¹⁹ Environmental factors include facial trauma and fractures both the prenatal and postnatal, cysts of the jaw,²⁰ tumours of the face along with their surgical treatment, hormonal disorders like acromegaly and gigantism, teratogens, ankylosis of temporomandibular joint,²¹ posture, abnormal breathing like mouth breathing and habits such as long term bottle and pacifier use, digit sucking, lip biting and lip sucking, pencil biting and nail biting,²² incorrect use of force during orthodontic treatment and also during usage of midline elastics and extraction of tooth.²³

EVALUATION OF OCCLUSAL CANT

The pattern of skeletal and dentoalveolar development is related to occlusal cant and can be classified based on facial asymmetry as with or without factors like asymmetric development of mandible, extruded molars on one side and also the asymmetric dentoalveolar development.²⁴ The occlusal cant in patients can be evaluated by frontal photographs, lateral cephalograms, clinical assessment and a three-dimensional imaging method. In clinical assessment for evaluation of the existence and degree of inclination of occlusal cant a tongue blade is placed between both the first molars.²⁵ In recent times, there has been an increase in the number of patients with TMJ disorders being referred to the orthodontic clinics. Facial asymmetry is less associated with the occlusal discrepancy in unilateral TMJ disorder, however because of the mandibular hypoplasia on the affected side there is an increase in the occlusal plane canting.²⁶ Studies and recent advances have enabled us to evaluate the occlusal cant, various methods are available to identify the side of cant and also to analyse the degree or extent of cant present and helps in categorizing the severity of OC. Based on the severity, the treatment for correction of the cant in occlusion can be planned. Hence, before commencing the treatment to determine the type of treatment required a detailed radiographic evaluation as well as other methods of measuring the cant need to be studied along with the clinical evaluation to obtain an aesthetic smile with good facial symmetry.

Radiography or Tomography

For the measurement and evaluation of the occlusal cant posteroanterior radiography is necessary. Analysis using PA radiographs helps in better evaluation as well as visual comparison of the asymmetry. Grummons frontal analysis and Sassouni analysis are commonly used to study the asymmetries. The asymmetry of facial points and planes and parallelism according to predetermined planes can be demonstrated with the help of these analyses. Head rotations and improper landmark identification are some of the drawbacks as they reduce the effectiveness of the posteroanterior radiographs.²⁷

However, PA radiographs are beneficial in cases of severe skeletal asymmetries and the treatment plan in such cases requires orthognathic surgery as one of the main steps in correction of canted occlusion.³

Some of the other radiographs that can be used are the basilar or submentovertex radiographs. They aid in the diagnosis of the dental arch deviation due to shift in the

midline, altered condylar positioning in cases of functional deviation of mandible, craniofacial as well as mandibular asymmetry. The asymmetries of the craniofacial complex and its components and their relationship to one another can be assessed.^{27,28}

Orthopantomographs can also be used for assessment of mandibular asymmetries. According to Habets et al. condylar and ramus height can be calculated to evaluate symmetry of condylar height. CT scans can be used because the complex three-dimensional nature of facial asymmetry can be studied easily.^{29,30}

Photographs

Photographs are one of the most traditional resources to study smile, aesthetics and also the cant in occlusion. Photographs can be used as one of the methods to evaluate the asymmetries of the soft tissue and also the cant of lips. Firstly, a photograph of patient's spontaneous smile has to be captured so that it records the maximum elevation of the upper lips. The photographs of the patient in occlusion are a part of the documentation and can be used to study the degree of cant. The plane of occlusion can be measured on the digital photographs with the average angle ranging from 2.15 - 2.9°. The degree of cant more than 1 along the corners of the mouth has shown the incidence rate of 28.6 % when the measurements were carried out in standardized frontal view photographs.³¹

Software

In recent times with the aid of computers and different software's like PowerPoint or keynote the use of reference lines with the software, facilitates in the analysis of the smile and the occlusal plane. One of the reference lines is the "bipupilar reference line" which can be transferred to the commissural region from its original position or can also be transferred to various regions like to the tip of cusp of canine or gingival contour, incisal edge depending upon the necessity. Following the contour of upper arch, lower lip, anterior or labial architecture other lines can be drawn in order to compare the symmetry between them.³²

Cant Identifying Device (CID)

This device uses a fox guide plane mounted along with spirit levels for evaluation of the cant in occlusion. For the assessment of the extent of the canting it consists of bubble in the spirit levels which aids in evaluation and definite insight of the cant in both anteroposterior as well as transverse dimensions. The bubble indicates the side to which the cant is present and also determines the extent of canting.

Variation in the left and right anteroposterior occlusal plane in lateral view can be studied in relation to the 'Ala - Tragus line' which in turn helps in evaluating the patient and better understanding so that the clinician can arrive at a proper diagnosis. This device is helpful in cases where the occlusal canting is not evident and also in cases where the soft tissue has compensated for the cant in occlusion.

This device has many advantages as it is economical as well as easily available, less bulky, comfortable for the patient and one of the main advantages is that the cant can be assessed

easily from both the frontal view as well as lateral view and can also be recorded easily in the photographs. The drawback of this device is that the quantification of the occlusal cant cannot be done into degrees or any form of measurement.³³

Measurement of Cant Using Stainless Steel Dental Ruler

The cant in maxillary occlusal plane due to fault in the development of maxilla unilaterally and also the cant in occlusal plane due to dentoalveolar causes can be measured using this method. The fabrication of the instrument is carried out by soldering 1 stainless steel ruler to the flat surface of the other stainless-steel ruler such that both the scales are perpendicular to each other. The horizontal part of the ruler is placed such that the under surface of the flat portion of the scale lies on the upper maxillary canine hook of the bracket and the patient is positioned in natural upright position. The vertical ruler lies on the contralateral side, the position of the ruler is adjusted so that it lies parallel to interpupillary line. The vertical distance measured tells the extent of cant in occlusion present and the amount of correction required. One of the main advantages of this device is that it is easy to use, economical, can be recorded in the photographs, can be easily fabricated and one of the major advantages is that the amount of cant present can be "quantified".³⁴

OC MANAGEMENT - TREATMENT ALTERNATIVES

The management of occlusal cant includes different treatment alternatives like orthognathic surgery, orthodontic therapy, or a combination treatment of both orthognathic surgery and orthodontic therapy.

Orthognathic Surgery

Surgical procedures for correction of occlusal cant involves single jaw or double jaw surgeries which are invasive and expensive.³⁵ But, the conservative orthodontic approach requires long term patient cooperation, and the results may be unsatisfactory for the patient.³⁶ Therefore, in cases with facial asymmetry and occlusal cant surgical procedures are said to be more effective.

The surgical approach depends upon the awareness of the patient with the severity of cant and aesthetic problems as well as jaw discrepancy in both vertical and sagittal directions. Before the surgery is carried out proper levelling of the teeth must be achieved by orthodontic treatment.³⁷ In cases with severe OC surgery of both the jaws may be required. The objectives of the treatment of patients with asymmetry of face mainly involves correction of deviation of maxillary as well as facial midline, symmetric canine display, correction of any deviation of chin.

In case of patients undergoing surgery of both the jaws a combination of Le Fort I osteotomy and mandibular bilateral sagittal split osteotomy or internal vertical ramus osteotomy is used. Extrusion of the side which is short and intrusion of the side which is longer are carried out in surgical correction of OC. The side for the vertical movement is selected based on the maxillary incisor display, angle of plane of occlusion,

vertical facial height. Studies have shown that intrusion of maxillary complex is stable when compared to vertical elongation.³⁸ Surgical intervention in cases with craniofacial asymmetry, defects of soft tissue, cleft lip and palate and reduced vertical height includes maxillary vertical elongation. In patients with craniofacial asymmetry additional surgical alternatives such as “distraction osteogenesis” and “Alloplastic bone graft” reconstruction are carried out.³⁹

Cant of soft tissue is one of the common complications of skeletal OC out of which lip cant is a major complaint.⁴⁰ It is characterised by difference in height amidst the corners along with distorted vermilion borders and deviated midline.⁴¹ Orbicularis oris muscle is one of the major muscles of lip and is closely related to the surrounding muscles. Hence, any deviation in mandible consequently affects the muscle causing deviation to the affected side. Orthognathic surgery creates an overall skeletal as well as soft tissue improvement including the lips. Lip asymmetries caused by mandibular deviations can be corrected by shifting the mentalis muscle towards the midline coinciding with face with the help of orthognathic surgery. One of the modalities of treatment of lip from frontal view is surgical split ramus osteotomy.^{42,43,44,45}

Orthodontic Camouflage Treatment

Treatment using orthodontic therapy involves either intrusion or extrusion of the arch using skeletal anchorage.

Intrusion and Extrusion of the Arches

In the situation with cant in occlusion in the anterior region because of the intruded teeth the management involves extrusion of the segment which is intruded using intermaxillary elastics. The use of these elastics cause extrusive force not only on the segment which needs extrusion but also on the opposing mandibular segment. Hence, this method can be used only in cases where extrusive forces are required in both the segments. Commonly cant in occlusion is confined to the anterior or posterior segment or upper and lower arch. In cases with OC in anterior segment and deep - bite malocclusion a combination treatment is required. Use of “intrusion arches” in situation with extruded teeth in the anterior segment allows in correction of both the deep bite as well as occlusal cant.⁴⁶

Usage of palatal arch and lingual arch can help in the correction of cant in occlusion of the posterior segment. Studies have also shown that activation of “tip back bend” on the side of occlusal cant in mandibular arch and “tip forward bend on the opposing segment of the arch can be used for the correction of cant as they have shown satisfactory results.⁴⁷

A biomechanical system described as rhythmic wire was developed by Kang et al. which aids in correction of occlusal cant. This biomechanical system consists of an extrusive wire, intrusive wire, two miniscrews (on maxillary and mandibular teeth) and to maintain torque of the posterior teeth in third order, a transpalatal lingual arch is given.⁴⁸ If the amount of intrusive force has to be reduced certain modifications like incorporation of helices or shortening of the length of the wire can be done. Both intrusion and extrusion arches have to be used simultaneously to maintain the occlusal contact. The side effects of these forces (intrusive and extrusive) cause molar tipping either buccally or lingually.

Yin - Yang Archwire

This is a prefabricated archwire which is made up of TMA as it has good springback properties. It has the shape which resembles “yin and yang” symbol on frontal view and laterally it resembles “Curve of Spee”.

It has a series of arch-wires i.e., 0.017×0.025 and 0.018×0.025 . For 018 slot the size of archwire used is 0.017×0.025 and for 022 slot 0.018×0.025 archwire is used. It is engaged molar to molar and has 60 degree and 100-degree configuration of which 100 degree is for the correction of cant whereas 60 degree is to maintain the achieved results.

The selection of the orientation of the archwire for correction of cant is done based on the the requirement. The upper side of the archwire is placed on the side where intrusion is required and lower side of the wire configuration is placed on the side where extrusion is required.⁴⁹

Skeletal Anchorage

Mandibular rotation as well as anterior vertical height is increased in cases where extrusion of molars is carried out. To reduce the anterior vertical height and to achieve more stable results intrusion of molars is considered. Alternative devices such as modified palatal appliances, headgears, elastomeric chains, removable appliance with elastics can be used in the treatment of intruded molars.^{35,50}

Undesired side effects, prolonged treatment time and reduced compliance of the patient occur on using anchorage systems for extrusion of molars that are used conventionally. Hence, for better anchorage control during the treatment for correction of the cant skeletal anchorage devices like mini plates and mini screws have been used lately. True intrusion of the molars along with increased delivery of force of up to 500 g, 150 – 250 g, 200 – 300 g can be achieved without any signs of resorption of the root. True intrusion can be achieved when the intrusive forces are applied on both the sides of the tooth, that is, palatally and buccally.

In recent times miniplates have been used widely as an anchorage system and also for the fixation of “osteotomy segments”.⁵¹ An intrusive force of about 400 g can be applied with the help of NiTi closed coil spring 4 - 7 days post insertion of the miniplate. 1.99 mm of molar intrusion was achieved within 5.5 months by Sherwood et al. whereas Ervedi et al. achieved up to 2.6 mm of molar intrusion in 5.1 months.

Combination of Orthodontic Camouflage and Orthognathic Surgery

The combination therapy includes the orthodontic treatment using skeletal anchorage system and also the surgical treatment. This type of treatment plan is implemented in cases where the cant in occlusion is because of over erupted maxillary posterior teeth on one side and with facial asymmetry.

The skeletal anchorage (miniscrews or miniplates) can be used for the correction of the cant in maxillary segment and the surgical treatment for correction of the asymmetry of the face like sagittal split osteotomy, ramus osteotomy etc can be carried out. This treatment method reduces the need for additional surgery like Le Fort I.

CONCLUSIONS

Occlusal canting is one of the common difficulties' clinicians faces in routine orthodontic practice. The cant in occlusion can be of various degrees and may also involve the symmetry of the face. The cant in occlusion is one of the main concerns for an aesthetic smile. The advances and awareness among the individuals to obtain an aesthetic smile have led to various treatment alternatives based on the severity of the occlusal cant. To achieve satisfactory outcome the clinician must examine and find the etiological factors and proper treatment planning has to be carried out based on the type of occlusal cant such that the outcome shows aesthetic smile along with good facial symmetry.

Financial or other competing interests: None.

Disclosure forms provided by the authors are available with the full text of this article at jemds.com.

REFERENCES

- [1] Janzen EK. A balanced smile--a most important treatment objective. *Am J Orthod* 1977;72(4):359-72.
- [2] Springer NC, Chang C, Fields HW, et al. Smile esthetics from the layperson's perspective. *Am J Orthod Dentofacial Orthop* 2011;139(1):e91-101.
- [3] Farret MM. Occlusal plane canting: a treatment alternative using skeletal anchorage. *Dental Press J Orthod* 2019;24(1):88-105.
- [4] Kasrovi PM, Meyer M, Nelson GD. Occlusion: an orthodontic perspective. *J Calif Dent Assoc* 2000;28(10):780-90.
- [5] Davies SJ, Gray RM, Sandler PJ, et al. Orthodontics and occlusion. *Br Dent J* 2001;191(10):539-49.
- [6] Okeson J. *Management of Temporomandibular Disorders and Occlusion*. 7th edn. St Louis, MO: Mosby 2013.
- [7] Kumar KPS, Tamizharasi S. Significance of curve of Spee: an orthodontic review. *J Pharm Bioallied Sci* 2012;4(Suppl 2):S323-8.
- [8] Pisulkar, Sweta K, Agrawal R, et al. Perception of buccal corridor space on smile aesthetics among specialty dentist and layperson. *J Int Soc Prev Community Dent* 2019;9(5):499-504.
- [9] Samman N, Tong AC, Cheung DL, et al. Analysis of 300 dentofacial deformities in Hong Kong. *Int J Adult Orthodon Orthognath Surg* 1992;7(3):181-5.
- [10] Haraguchi S, Takada K, Yasuda Y. Facial asymmetry in subjects with skeletal class III deformity. *Angle Orthod* 2002;72(1):28-35.
- [11] Chew MT. Spectrum and management of dentofacial deformities in a multiethnic Asian population. *Angle Orthod* 2006;76(5):806-9.
- [12] Celikoglu M, Akpınar S, Yavuz I. The pattern of malocclusion in a sample of orthodontic patients from Turkey. *Med Oral Patol Oral Cir Bucal* 2010;15(5):e791-6.
- [13] Good S, Edler R, Wertheim D, et al. A computerized photographic assessment of the relationship between skeletal discrepancy and mandibular outline asymmetry. *Eur J Orthod* 2006;28(2):97-102.
- [14] Proffit WR, Phillips C, Dann C 4th. Who seeks surgical-orthodontic treatment? *Int J Adult Orthodon Orthognath Surg* 1990;5(3):153-60.
- [15] Bishara SE, Burkey PS, Kharouf JG. Dental and facial asymmetries: a review. *Angle Orthod* 1994;64(2):89-98.
- [16] Karia H, Shrivastav S, Karia AK. Three-dimensional evaluation of the airway spaces in patients with and without cleft lip and palate: a digital volume tomographic study. *Am J Orthod Dentofacial Orthop* 2017;152(3):371-81.
- [17] Pisulkar SK, Agrawal R, Belkhode V, et al. Perception of buccal corridor space on smile aesthetics among specialty dentist and layperson. *J Int Soc Prev Community Dent* 2019;9(5):499-504.
- [18] Xavier SP, Ribeiro MC, Sicchieri LG, et al. Clinical, microscopic and imaging findings associated to McCune-albright syndrome: report of two cases. *Braz Dent J* 2008;19(2):165-70.
- [19] Maruko E, Hayes C, Evans CA, et al. Hypodontia in hemifacial microsomia. *Cleft Palate Craniofac J* 2001;38(1):15-9.
- [20] Rogers GF, Greene AK, Oh AK, et al. Zygomaticotemporal synostosis: a rare cause of progressive facial asymmetry. *Cleft Palate Craniofac J* 2007;44(1):106-11.
- [21] Peitsch WK, Keefer CH, Labrie RA, et al. Incidence of cranial asymmetry in healthy newborns. *Pediatrics* 2002;110(6):e72.
- [22] Das UM, Keerthi R, Ashwin DP, et al. Ankylosis of temporomandibular joint in children. *J Indian Soc Pedod Prev Dent* 2009;27(2):116-20.
- [23] Lagana G, Masucci C, Fabi F, et al. Prevalence of malocclusions, oral habits and orthodontic treatment need in a 7-to 15-year-old school children population in Tirana. *Prog Orthod* 2013;14:12.
- [24] Caglaroglu M, Kilic N, Erdem A. Effects of early unilateral first molar extraction on skeletal asymmetry. *Am J Orthod Dentofacial Orthop* 2008;134(2):270-5.
- [25] Cheong YW, Lo LJ. Facial asymmetry: etiology, evaluation and management. *Chang Gung Med J* 2011;34(4):341-51.
- [26] Cho JH, Kim EJ, Kim BC, et al. Correlations of frontal lip-line canting with craniofacial morphology and muscular activity. *Am J Orthod Dentofacial Orthop* 2007;132(3):278.e7-e14.
- [27] Perrott DH, Umeda H, Kaban LB. Costochondral graft construction/reconstruction of the ramus/condyle unit: longterm follow-up. *Int J Oral Maxillofac Surg* 1994;23(6 Pt 1):321-8.
- [28] Uzel I, Enacar A. Ortodontide Sefalometri. In: Ukurova C, Adana U, eds. *Turkey: Universitesi Basimevi* 2000.
- [29] Forsberg CT, Burstone CJ, Hanley KJ. Diagnosis and treatment planning of skeletal asymmetry with the submental-vertical radiograph. *Am J Orthod* 1984;85(5):224-37.
- [30] Habets LL, Bezuur JN, Naeiji M, et al. The orthopantomogram, an aid in diagnosis of temporomandibular joint problems. II. The vertical symmetry. *J Oral Rehabil* 1988;15(5):465-71.
- [31] Park SH, Yu HS, Kim KD, et al. A proposal for a new analysis of craniofacial morphology by 3-dimensional computed tomography. *Am J Orthod Dentofacial Orthop* 2006;129(5):600.e23-34.

- [32] Ferrario VF, Sforza C, Poggio CE, et al. Distance from symmetry: a three-dimensional evaluation of facial asymmetry. *J Oral Maxillofac Surg* 1994;52(11):1126-32.
- [33] Edler R, Wertheim D, Greenhill D. Clinical and computerized assessment of mandibular asymmetry. *Eur J Orthod* 2001;23(5):485-94.
- [34] Jayakrishnan, Mithun K, Shetty KN, et al. Clinical innovation CANT identification device in orthodontics--enabling early detection of occlusal CANT. *Int J Innovative Sci Res Tech* 2020;5(2):2456-65.
- [35] Naini FB, Messiha A, Gill DS. Chair side measuring instrument for quantification of the extent of a transverse maxillary occlusal plane cant. *Maxillofac Plast Reconstr Surg* 2019;41(1):21.
- [36] Park YC, Lee SY, Kim DH, et al. Intrusion of posterior teeth using mini-screw implants. *Am J Orthod Dentofacial Orthop* 2003;123(6):690-4.
- [37] Hanson PR, Melugin MB. Surgical/orthodontic treatment of mandibular asymmetries. *Semin Orthod* 2009;5(2):268-78.
- [38] Polley JW, Figueroa A, Cohen M. Leveling of the occlusal plane during model surgery. *J Craniofac Surg* 1993;4(4):266-7.
- [39] Ko EWC, Huang CS, Chen YR. Characteristics and corrective outcome of face asymmetry by orthognathic surgery. *J Oral Maxillofac Surg* 2009;67(10):2201-9.
- [40] Ko EW, Hung KF, Huang CS, et al. Correction of facial asymmetry with multiplanar mandible distraction: a one-year follow-up study. *Cleft Palate Craniofac J* 2004;41(1):5-12.
- [41] Laufer D, Glick D, Gutman D, et al. Patient motivation and response to surgical correction of prognathism. *Oral Surg Oral Med Oral Pathol* 1976;41(3):309-13.
- [42] Benson KJ, Laskin DM. Upper lip asymmetry in adults during smiling. *J Oral Maxillofac Surg* 2001;59(4):396-8.
- [43] Kim YH, Jeon J, Rhee JT, et al. Change of lip cant after bimaxillary orthognathic surgery. *J Oral Maxillofac Surg* 2010;68(5):1106-11.
- [44] Pont GD. Retromolar osteotomy for the correction of prognathism. *J Oral Surg Anesth Hosp Dent Serv* 1961;19:42-7.
- [45] Obwegeser H. The indications for surgical correction of mandibular deformity by the sagittal splitting technique. *Br J Oral Surg* 1964;1:157-71.
- [46] Hwang HS, Min YS, Lee SC, et al. Change of lip-line cant after 1-jaw orthognathic surgery in patients with mandibular asymmetry. *Am J Orthod Dentofacial Orthop* 2009;136(4):564-9.
- [47] Burstone CJ. The segmental arch approach to space closure. *Am J Orthod* 1982;82(5):361-8.
- [48] Burstone CJ. Precision lingual arches, active applications. *J Clin Orthod* 1989;23(2):101-9.
- [49] Kang YG, Nam JH, Park YG. Use of rhythmic wire system with miniscrews to correct occlusal-plane canting. *Am J Orthod Dentofacial Orthop* 2010;137(4):540-7.
- [50] Liou EJW, Mehta K, Lin JCY. An archwire for noninvasive improvement of occlusal cant and soft tissue chin deviation. *APOS Trends Orthod* 2019;9(1):19-25.
- [51] Yao CC, Wu CB, Wu HY, et al. Intrusion of the overerupted upper left first and second molars by mini-implants with partial-fixed orthodontic appliances: a case report. *Angle Orthod* 2004;74(4):550-7.
- [52] Sherwood KH, Burch JG, Thompson WJ. Closing anterior open bites by intruding molars with titanium miniplate anchorage. *Am J Orthod Dentofacial Orthop* 2002;122(6):593-600.