

Review

Occlusal Cant: Etiology, Evaluation, and Management

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ABSTRACT

Occlusal cant is an important factor affecting smile esthetics. The dynamic display zone includes lateral, vertical, and anteroposterior aspects, as well as the cant of the occlusal plane. Smile design and mechanotherapy must take into account an esthetic plane of occlusion. The purpose of this review is to describe occlusal cant, examine its diagnosis, and explain the treatment alternatives for this condition. (*Turkish J Orthod.* 2014;27:174–180)

KEY WORDS: Occlusal plane, Occlusal cant, Smile esthetics, Smile design, Occlusion

INTRODUCTION

The most important esthetic goal in orthodontics is to achieve a “balanced” smile,¹ which can be best described as an appropriate positioning of the teeth and gingival scaffold within the dynamic display zone. The display zone are affected by the size, shape, position, and color of the displayed teeth as well as the gingival contour, buccal corridor, and framing of the lips.^{2,3} Smile design and mechanotherapy must take into account an esthetic plane of occlusion, which is often different from the natural plane of occlusion.⁴ In this review, occlusal cant (OC) in the frontal plane is examined.

Occlusal Plane

The occlusal plane (OP) is an imaginary surface that is anatomically related to the cranium. Theoretically, it touches the incisal edges of the incisors and the tips of the occluding surfaces of the posterior teeth. The OP is not, in fact, a plane, but rather represents the mean curvature of this surface. Therefore, the OP is the plane that would be established if a line were drawn through all the buccal cusp tips and incisal edges of the mandibular teeth and then broadened into a plane to include the lingual cusp tips, continuing across the arch to include the buccal and lingual cusp tips of the opposite side.^{5,6} The OP of the dental arches is

curved in a manner that permits maximal utilization of the tooth contacts during chewing.⁷ This curvature of the dental arches has been referred to as the curve of Spee.⁸ A second curve associated with the OP can be observed from a frontal view and is called the curve of Wilson.⁷ In cephalometric radiographs (in the sagittal plane), the OP is defined as a line that joins the midpoint of the overlap of the mesiobuccal cusp of the first molar and the incisal edges of the incisors. In posteroanterior (PA) radiographs (in the vertical plane), the OP is defined as a line that joins the buccal cusps of the right and left upper first molars in a transversal direction.

The OP adapts to the alterations that occur with age, vertebral maturation, and changes in dental position.⁹ Lateral cephalometric studies evaluating the OP in a sagittal direction indicated that the inclination of the OP alters according to changes in craniofacial structures during craniofacial growth and development.⁹ Schudy¹⁰ stated that condylar growth (as related to vertical growth) is the key to changes in the OP.

In the frontal plane, changes in the OP result from posterior rotation and relocation of the maxilla and

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To cite this article: Şenışık NE, Hasipek S. Occlusal cant: etiology, evaluation, and management. *Turkish J Orthod.* 2014;27:174–180 (DOI: <http://dx.doi.org/10.13076/TJO-D-14-00034>)

Date Submitted: November 2014. Date Accepted: March 2015. Copyright 2014 by Turkish Orthodontic Society

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mandible in a vertical direction. The inclination of the OP increases in a clockwise direction during growth.¹¹ Symmetric growth and development enables the conservation of the angles between the cranial planes and OP during an increase in vertical dimensions.¹²

Although changes in the inclination of the OP in the sagittal plane are associated with growth and development, changes in the inclination of the OP in the vertical plane result from asymmetric growth of the craniofacial structures and lead to an asymmetric OP; this is defined as OC.¹³

Occlusal Cant

Occlusal plane canting in the vertical plane is one of the parameters affecting smile esthetics and originates from facial asymmetry and/or vertical position asymmetry of the right and/or left quadrants of the dental arches without facial asymmetry.

Occlusal cant is frequently associated with facial asymmetry; the reported frequency of facial asymmetry in cases involving this condition varies between 21% and 80%.^{14–18} This wide range may result from differences between reports in characteristics of facial deformity, types of skeletal malocclusion, age, or ethnicity. In addition, observed differences in the proportion of facial asymmetry in OC may be due to variations in methods, symmetry criteria, or measurement sensitivity between studies.^{14,16,18–21}

Good et al²⁰ indicated that the incidence of asymmetry increases in patients with skeletal class III malocclusion and increased lower facial height. According to Severt and Proffit,¹⁵ OC is found in 41% of patients with class III malocclusion.

Symmetry and Asymmetry Perception

It has been demonstrated that symmetric faces are more attractive but not more so than less symmetric faces.²² However, preferences for symmetry cannot solely explain the attractiveness of average faces.²³ Usually, symmetric faces are preferred by individuals; however, a person's preference for symmetry was not correlated with their ability to detect it.²⁴ Different perceptual mechanisms play a part in symmetry preference and detection.²⁴ Hönn and Göz²⁵ demonstrated that women's preferences for attractive male faces are greatly influenced by their menstrual cycles and environment. The ideal of beauty is subject to certain fluctuations.²⁵ The perception of OC varies between lay persons, general dentists, and orthodontists.

Oliveres et al²⁶ concluded that an OC of 2° was acceptable to lay persons, general dentists, and orthodontists. In addition, lay persons and general dentists found OC more acceptable than orthodontists. Lay persons failed to detect the existence of an OC reaching 3–4°. Padwa et al²⁷ concluded that 4° is the threshold for detection of OC.

Etiologic Factors in Asymmetry and Occlusal Cant

Determination of asymmetries and classification of cases is complicated by the multifactorial nature of asymmetry. The etiology of asymmetry can be classified as consisting of hereditary and environmental factors.²⁸ Cleft lip and palate,²⁹ hemifacial microsomia,³⁰ juvenile idiopathic arthritis,³¹ Treacher Collins syndrome,³² Albright syndrome,³³ Apert syndrome, Crouzon syndrome,³⁴ and craniosynostosis³⁵ are the common hereditary factors that lead to facial asymmetry and OC. Environmental factors affecting facial asymmetry and OC include facial trauma and fractures (prenatal and postnatal),³⁶ jaw cysts, and facial tumors as well as their surgical treatment,³⁷ teratogens,³⁸ hormonal disorders (such as gigantism or acromegaly),³⁹ Romberg syndrome,⁴⁰ posture,⁴¹ temporomandibular joint (TMJ) ankylosis,⁴² muscular disorders,⁴³ abnormal mouth breathing, habits such as finger or lip sucking, long-term bottle or pacifier use, pencil biting and nail biting,⁴⁴ tooth extraction and carries,⁴⁵ and incorrect use of force during orthodontic treatment or when using midline elastics.⁴⁶

Evaluation of Occlusal Cant

Occlusal cant is related to the pattern of skeletal and/or dentoalveolar development and can be classified with or without facial asymmetry due to asymmetric development of the mandible, unilateral extruded molars, or asymmetric dentoalveolar development.⁴⁷ Patients with OC are evaluated by clinical assessment, frontal photographs, cephalometry, and 3-dimensional imaging methods.

During clinical assessment, a tongue blade is placed across both first molars to evaluate the existence and degree of inclination of OC.⁴⁸ Recently, the number of patients referred to orthodontic clinics as a result of TMJ disorders has been increasing. In patients with unilateral TMJ disorder, facial asymmetry is less associated with occlusal discrepancy; however, canting of the OP in these patients is increased because of mandibular hypoplasia on the affected side.⁴⁹ Detailed clinical

examination and radiological evaluation of the TMJ are essential in such patients.

Posteroanterior radiography is also necessary in the evaluation and objective measurement of OC. Analysis of PA radiographs allows easy visual comparison of asymmetry.²⁷ The most commonly used asymmetry analyses are Grummons frontal analysis and Sassouni analysis.⁵⁰ These analyses demonstrate the parallelism and asymmetry of facial points and planes according to predetermined planes.⁵¹ The horizontal distance from the menton to the midsagittal plane on PA radiographs is measured as deviation.⁵² The angle of the OP to the true horizontal plane is measured as the angle of OC.²⁷ It has been demonstrated that the degree of OC relative to the true horizontal plane as measured cephalometrically in the frontal plane is equal to the linear millimeter difference between the right and left medial canthus and the right and left canine tips.⁵³ However, the effectiveness of PA radiographs may be reduced by head rotation or improper landmark identification.

In the presence of asymmetry, basilar/submento-vertex (SMV) radiographs are also useful. The SMV radiographs can be used to diagnose dental arch deviations resulting from midline shifts, craniofacial asymmetry, condylar position in functional mandibular deviation, mandible asymmetry, and, in particular, maxillary asymmetry in cleft lip and palate patients.⁵⁰ The SMV radiographs allow the assessment of asymmetry within each component part of the craniofacial complex as well as the relative relationship of these parts to one another.⁵⁴ In addition, SMV radiographs are less vulnerable to head rotation.⁵⁵

Orthopantomograms provide information about mandibular asymmetry. Habets et al⁵⁶ described condylar height symmetry calculated by condylar and ramus heights on orthopantomograms.

Three-dimensional computed tomography (CT) can provide information for use in diagnosis and treatment planning.⁵⁷ Because of the complex three-dimensional nature of facial asymmetry, CT scans have become routine in the evaluation of asymmetry cases that cannot be assessed using conventional methods.

The evaluation of frontal facial photographs is a diagnostic tool used to evaluate soft-tissue asymmetry and lip cant.⁵⁸ It was concluded that an OP angle of 2.15–2.90° on a digital photograph is acceptable.⁵⁹ The incidence of a cant greater than 1° between the bilateral mouth corners was found to

be 28.6% when the face was measured on standardized frontal facial photographs.⁶⁰

OC Management: Treatment Alternatives

Orthognathic surgery, orthodontic therapy, or a combination of orthognathic surgery and orthodontic therapy are used as treatment alternatives in the compensation of OC.

Orthognathic surgery. Although procedures involving single or double jaw surgery are invasive and expensive,⁶¹ conservative orthodontic treatment methods also have limitations as they require patient cooperation and can produce unsatisfactory results for subjects.⁶² Therefore, surgical procedures are effective and valid in patients with OC and/or facial asymmetry.

In the treatment of facial asymmetry, the choice of surgical intervention depends on the patient's self-awareness of the esthetic problem as well as the severity of the OC and jaw discrepancy in sagittal and vertical directions. Leveling of the OP is generally required before surgery.⁶³ Double jaw surgery may be required in patients with dramatic OC. In the treatment of patients with facial asymmetry, the main purposes of orthognathic surgery are to correct facial and maxillary midline deviation, level the oral commissure, obtain symmetric display of the canine teeth, and correct chin deviation according to the normal facial midline. In double jaw surgery patients, a combination of Le Fort I osteotomy and mandibular bilateral sagittal split osteotomy or internal vertical ramus osteotomy is used.

Surgical correction of maxillary OC is based on extrusion of the short side and intrusion of the long side of the maxillary complex. The selection of the side for vertical movement depends on maxillary incisor display, OP angle in the sagittal direction, and anterior vertical facial height. However, it is considered that surgical intrusion of the maxillary complex is a more stable process than maxillary vertical elongation.⁶⁴ In patients with hemifacial microsomia, craniofacial asymmetry, and cleft lip and palate, soft-tissue defects and decreased vertical height may be present on the affected side. Surgical intervention in these patients can involve maxillary vertical elongation. Distraction osteogenesis and alloplastic bone graft reconstruction are additional surgical alternatives for patients with craniofacial asymmetry.⁶⁵

Most patients with skeletal OC also have soft-tissue cant.⁶⁶ Lip cant is a major complaint in such patients and is evident when observing facial configuration.²⁸ Lip cant is also referred to as lip

asymmetry and is characterized by a height difference between the corners of the mouth, with distorted vermillion borders of the upper and lower lips, and deviation of the mouth midline from the facial midline.⁶⁷ The vermillion area is increased on the deviated side when compared with the contralateral side.²¹ Musculus orbicularis oris is the major muscle of the lips and consists of fibers that completely encircle the mouth. This muscle is closely related to the other mimetic muscles.⁶⁸ Therefore, deviation of the mandible affects these muscles and pulls the orbicularis oris to the deviated side; consequently, asymmetric lips arise. Orthognathic surgery results in significant improvements not only in the facial skeleton but also in the upper and lower lips.⁶⁹ Asymmetry of the lips caused by deviation of the mandible can be almost completely corrected by movement of the mentalis muscle to the midline of the facial skeleton with orthognathic treatment.⁵⁸ Orthognathic surgery, especially surgical split ramus osteotomy, is an effective treatment modality for recovery of the lip from a frontal view.^{70–72}

Orthodontic camouflage treatment. Compensation of OC with orthodontic therapy involves arch intrusion/extrusion and use of skeletal anchorage.

Intrusion and extrusion of the arches. In the anterior region, conventional treatment of OC caused by intruded teeth is based on extrusion of the intruded segment with intermaxillary elastics. Application of intermaxillary elastics causes extrusive forces to both the maxillary and mandibular arches. Therefore, this technique is limited in cases where OC is caused by both extruded teeth on one side and intruded teeth on the other side. Usually, OC is localized in the upper and lower arch or anterior or posterior segment. A combination of deep bite and OC treatment is needed in patients with anterior OC and deep bite malocclusion.⁷³ Application of a 0.017 × 0.025 titanium molybdenum alloy intrusion arch to the anterior segment of the side with extruded teeth allows improvement of both OC and the deep bite. Unilateral extrusion can be obtained with a cantilever extrusion arch in the anterior segment during the treatment of OC patients without a deep bite.⁷³ Posterior OC can be eliminated using a palatal arch in the maxilla and a lingual arch in the mandible.⁷⁴ For the treatment of mandibular OC, tip back activation on the side of OC and tip forward activation on the contralateral side is successful.⁷⁴

Kang et al⁷⁵ developed a biomechanical system known as rhythmic wire to correct canted OP. This system consists of 2 miniscrews (on the maxillary

and mandibular teeth), intrusion wire, extrusion wire, and a transpalatal lingual arch to maintain the third-order torque of the posterior teeth.⁷⁵ If a reduction in the strength of intrusion force is desired, the length of the wire can be shortened or helices may be added to the wires. Intrusion and extrusion arches should be used simultaneously to ensure the integrity of occlusal contact.⁷⁶

Undesired movements such as buccal or lingual tipping of the molars can occur with extrusion or intrusion. To reduce the side effects of intrusion and extrusion, transpalatal or lingual arches can be used.⁷⁵

Skeletal anchorage. The treatment of OC is based on intrusion of extruded molars and extrusion of intruded molars. Extrusion of molars can increase the posterior rotation tendency of the mandible as well as the anterior vertical height. Intrusion of molars is more stable and decreases the anterior vertical height.⁷⁷ In the treatment of intruded molars, the use of alternative devices such as occipital headgear, removable appliances with elastics, modified palatal appliances, elastomeric chain, and magnets has been suggested.^{61,78} Use of conventional anchorage during extrusion of molars leads to undesired side effects, a decrease in patient cooperation, and increased duration of therapy.⁷⁹ Therefore, the use of miniscrews and miniplates as skeletal anchorage devices has been introduced for the intrusion of molars.⁶¹ Although the optimum intrusion force needed for molar intrusion with miniscrews has not yet been reported, increased force levels can be used with miniscrews and miniplates.^{61,80} It has been demonstrated that genuine intrusion of molars was obtained with forces of 500 g,⁸⁰ 200–300 g,⁶¹ and 150–250 g⁷⁷ without root resorption. To prevent flaring and rotation during intrusion, intrusion forces should be applied both buccally and lingually.^{61,81}

Molar intrusion can also be achieved using miniplates.^{80,82,83} Use of miniplates has become widespread in orthodontics for skeletal anchorage and fixation of osteotomy segments during surgical procedures.⁸² Several studies have revealed that the zygomatic buttress area is an efficient anchorage area for managing intrusion movement of the posterior maxillary segment.^{82,84,85} Following 4–7 days of anchor plate insertion, an intrusion force of up to 400 g can be applied with nickel-titanium closed coil springs.⁸⁶ Prevention of potential molar tipping during intrusion can be achieved with a transpalatal arch.⁸⁶ Sherwood et al.⁸² achieved

molar intrusion of 1.99 mm in 5.5 months,⁸² while Erverdi *et al.*⁸⁶ demonstrated molar intrusion of 2.6 mm in 5.1 months.⁸⁶ In addition, the duration of corticotomy-enhanced intrusion of the posterior maxillary segment with miniplate anchorage is shorter.⁸⁷ A shorter intrusion duration is advantageous in terms of the risk of devitalization and root resorption.⁸⁸ Hwang and Lee⁸⁹ suggested that after corticotomy-enhanced intrusion, 90 g of force application is sufficient to prevent the relapse of molar intrusion.

Orthodontic camouflage and orthognathic surgery combination therapy. This type of therapy includes OC treatment with skeletal anchorage (miniscrews or miniplates) in the maxilla and orthognathic surgery in the mandible to provide facial symmetry. In patients with OC and facial asymmetry, OC caused by unilateral overerupted posterior maxillary teeth can be treated with miniscrews. Therefore, the requirement for Le Fort I osteotomy can be eliminated.⁹⁰ After OC treatment with miniscrews, the alternative surgical intervention techniques for facial asymmetry include sagittal split ramus osteotomy and genioplasty⁹¹ and/or intraoral vertical ramus osteotomy.⁹²

CONCLUSION

Occlusal plane canting in the vertical plane is one of the parameters affecting smile esthetics and originates from facial asymmetry and/or vertical position asymmetry of the right and/or left quadrants of the dental arches without facial asymmetry. The number of individuals with OC is rising, and people are becoming more aware of this issue. To obtain satisfactory treatment results in individuals with OC, the etiologic factors of OC should be examined, the classification of OC should be considered, and the benefits of alternative treatment choices should be discussed.

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