ORIGINAL ARTICLE

An interim analysis of the maxillary canine in determining the maxillary occlusal plane

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ABSTRACT

Aim: A pilot study on dentate subjects was done to evaluate the relationship of the incisal edge exposures of the maxillary central incisor (CI) and maxillary canine to the maxillary lip at rest, to the maxillary lip length, and the influential effects of incisal wear and anteroposterior skeletal relation. **Materials and Methods:** Thirty males and 67 females of Indian origin and age group 15-59 years were examined. A calibrated manual vernier caliper was used to record the incisal exposures of the maxillary left CI and canine to the maxillary lip at rest and the maxillary lip length. The tooth wear index by Smith and Knight (1984) was used to assess the extent and severity of the incisal attrition. Anteroposterior skeletal relation was assessed using soft tissue cephalometric points. A descriptive statistical analysis and Pearson's correlation analysis was done. **Results:** On descriptive analysis of the data recorded, 94% of the female subjects recorded a mean CI exposure of 3.25 mm to the maxillary lip at rest while 91% of the female subjects recorded a mean canine exposure of 0.29 mm. 93% of the male subjects recorded a mean CI exposure of 2.63 mm to the maxillary lip at rest. 80% of the male subjects recorded a mean canine exposure of −0.42 mm to the maxillary lip at rest. Canine displayed a narrow range of tooth visibility. In both genders, CI exposure to the mean lip length averaged 1-3 mm and the canine exposure to the mean lip length averaged −1-0 mm. CI and canine incisal edge exposures decreased with an increased incisal wear. CI exposure averaged 0-3 mm and canine exposures averaged −1-1 mm. Class II and Class I skeletal relation observed an increased CI exposure of 3 mm and 2.4 mm respectively compared to Class III (2.125 mm). Increased canine exposures were observed for Class III (0.3 mm) and Class II (0 mm) compared to Class I (−0.7 mm). Pearson's correlative analysis demonstrated a highly significant positive correlation of the canine with a *P* value of 0.01. **Conclusion:** Within the scope of this study, descriptive analysis demonstrated a linear favorable relationship of the canine to the CI. Correlative analysis also demonstrated a favorable relationship of canine to CI with borderline significance of anteroposterior relationship.

Key words: Anterior occlusal plane, anteroposterior skeletal relation, correlative analysis, incisal attrition, maxillary canine exposure, maxillary central incisor exposure

Introduction

The ultimate aim of a restorative dentist is to rehabilitate the patient to normal contour, comfort, function, esthetics and health of the stomatognathic system. Anterior teeth serve as main determinants of esthetics and phonetics.

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In patients with missing anterior teeth, determining the vertical positions of the maxillary anterior teeth is an important criterion.

Literature has cited various guidelines in establishing the vertical maxillary incisal edge position during the fabrication of the maxillary dentures. These include phonetic guidelines, the vertical relationship of the central incisor (CI) with the lip at repose and the smile line.

Zarb and Bolender[1] observed the importance of labiodentals sounds in determining the vertical position of the maxillary anterior teeth. Pound[2] emphasized the use of phonetics in determining the VDO for most

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patients and its significance in treating Class II and tongue thrusting patients. Runte *et al*.[3] stressed maintaining the original tooth position accurately during artificial tooth placement as the maxillary incisor position influences /s/ sound production.

Frush and Fischer[4] stated the "smile line" as a guide in determining the vertical positioning of the maxillary anterior. Smiling line has been termed as a curve running through the incisal edges of the CI curving upward to the lateral incisors and to the tips of the canines. Passia *et al*.[5] emphasized the smile line as a valid tool in esthetic appearance of a smile.

Winkler,[6] Heartwell *et al*.[7] and Fenn *et al*.[8] have observed that the placement of the incisal edges of maxillary CIs is approximately 1-2 mm below the maxillary lip in repose for an acceptable esthetics.

Misch[9] has suggested the maxillary canine as a reliable guideline as opposed to the maxillary CI in determining the vertical relation of the maxillary anterior teeth. He observed that to the maxillary lip at repose, on a horizontal plane, − 1 mm to 1 mm of cusp tip exposure of the maxillary canine was recorded compared to the 3-4 mm of incisor edge exposure of the maxillary CI. The values of the maxillary canine exposures recorded were consistent and depicted a narrow range in both genders of all ages unlike the wide range of exposure of the CIs. But the measurements recorded were average means of a single parameter; evaluating the range of exposure of the incisor edge and cusp tip of the maxillary CI and maxillary canine to the lip at repose. This hypothesis was further analyzed considering other parameters as well.

A pilot study on dentate subjects was conducted to evaluate the relationship of the incisal edges of the maxillary CI and maxillary canine to the maxillary lip at rest, to the maxillary lip length, the influence of incisal wear and anteroposterior skeletal relation to exposure of the incisal edges. The resultant findings would aid in determining the prospects of the canine position as a guideline in establishing the maxillary anterior incisal edge position when restoring edentulous patients.

Materials and Methods

An interim analysis was conducted on 30 dentate males and 67 dentate females of Indian origin and age group 15-59 years to evaluate the relationship of the incisal edge exposures of the maxillary CI and maxillary canine to the maxillary lip at rest, to the maxillary lip length, and the influential effects of incisal wear and anteroposterior skeletal relation.

Ethical clearance was obtained from the ethical committee framed by the institution. It confirmed to the provisions of the Declaration of Helsinki. An informed consent was obtained from each subject.

The selection criteria required subjects to have all of their natural anterior teeth and at least first molar occlusion. The left maxillary CI and canine were taken as index teeth. Subjects with an history of surgery involving the lower third of the face, history of orthodontics and any evidence of incisal wear of score greater than 2 tooth wear index (TWI) were excluded. Subjects with restored anterior teeth were also excluded. Age brackets were designated: < 20 years, 20-29 years, 30-39 years, and > 40 years [Table 1].

With each patient seated upright and head unsupported, all measurements were made by the same examiner. Each patient was asked to pronounce "emma" and relax his/her face and lower jaw.[10]

A calibrated manual vernier caliper was the armamentarium used. The distance (in the nearest mm) from the most inferior point of the vermilion border of the maxillary lip at rest to the incisal edge of the left maxillary CI was measured and recorded [Figure 1a]. The procedure was repeated to the cusp tip of the left maxillary canine [Figure 1b]. Each measurement was made thrice by the same examiner, and the average reading was used. The readings obtained were used in evaluating the relationship of the incisal edges exposures of the maxillary CI and canine to the maxillary lip at rest.

Maxillary lip length was measured using soft tissue cephalometric points.[11] The vertical distance between soft tissue subnasale and stomion superius was calculated as the maxillary lip length. Soft tissue subnasale is the point at which the columella (nasal septum) merges with the upper lip in the midsagittal plane. Stomiom superius is the most inferior point on the curve of the upper lip [Figure 1c]. Exposure of the tooth beyond the lower border of maxillary lip was taken as positive and negative exposure was assigned to an unexposed tooth.

The TWI by Smith and Knight (1984) was used to assess the extent and severity of the incisal attrition.[12]

Table 1: Age Brackets

Age	*No. of subjects*
< 20	4
20-29	66
30-39	15
>40	12

Assessment of the anteroposterior skeletal relation was done by placing the index and the middle fingers at the soft tissue Point A and Point B.[13,14] Cephalometrically, Point A or Subspinale is the crainometric point that is deepest and the most posterior point in the midline on the alveolar process. Point B or supramentale is the deepest point on the profile curvature from pogonion to infradentale. A straight level of the fingers indicated Class I skeletal pattern; the fingers pointing upwards indicated Class II and the fingers pointing downward indicated Class III skeletal pattern [Figure 1d]. Each measurement was made thrice by the same examiner and average values taken.

Using the statistical analysis software SPSS 11.0 (SPSS Inc., Chicago, IL, USA), a descriptive analysis and Pearson's correlation analysis was done to evaluate the relationship of the incisal edges of the maxillary CI and maxillary canine to the maxillary lip at rest, the relationship of the exposure of the incisal edges to the maxillary lip length, and the influence of incisal wear and anteroposterior skeletal relation to the exposure of the incisal edges.

Results

In the female group, 94% of the subjects recorded a range of −1-5 mm CI exposure with a mean of 3.25 mm to the maxillary lip at rest. 91% of the subjects recorded a range of −2-2 mm of canine exposure with a mean of 0.29 mm [Figure 2a and b].

In the male group, 93% of the subjects recorded a range of 0-5 mm of CI exposure with a mean of 2.63 mm to the maxillary lip at rest [Figure 2c]. 80% of the subjects recorded a range of −2-2 mm of canine exposure with a mean of −0.42 mm to the maxillary lip at rest [Figure 2d]. A highly significant positive correlation of *P* value 0.01 was observed for the canine.

A negative correlation was observed of the CI and canine incisal edge exposures as age advanced. A slightly significant *P* value of 0.01 for CI exposure and an insignificant *P* value of 0.72 for canine exposure with age were observed.

In both genders, CI exposure to the mean lip length averaged 1-3 mm and the canine exposure the mean to lip length averaged −1-0 mm [Figure 3a and b]. As lip length increased, CI exposure and canine exposure decreased. A negative correlation with insignificant *P* values of 0.56 and 0.76 was recorded respectively.

Central incisor and canine incisal edge exposures decreased with an increased incisal wear. CI exposure averaged 0-3 mm and canine exposures averaged −1-1 mm [Figure 4a and b]. An insufficient correlation with insignificant *P* values of 0.77 and 0.94 respectively was recorded.

Class II and Class I skeletal relation observed an increased CI exposure of 3 mm and 2.4 mm respectively compared to Class III (2.125 mm). Increased canine exposures were observed for Class III (0.3 mm) and Class II (0 mm) compared to Class I (−0.7 mm) [Figure 4c and d]. An insufficient correlation of anteroposterior skeletal relation to CI and canine exposures were observed with insignificant *P* values of 0.78 and 0.94 respectively.

Discussion

The vertical and horizontal positioning of the maxillary anterior teeth plays a crucial role in determining esthetics and phonetics. Inappropriate placement of the maxillary

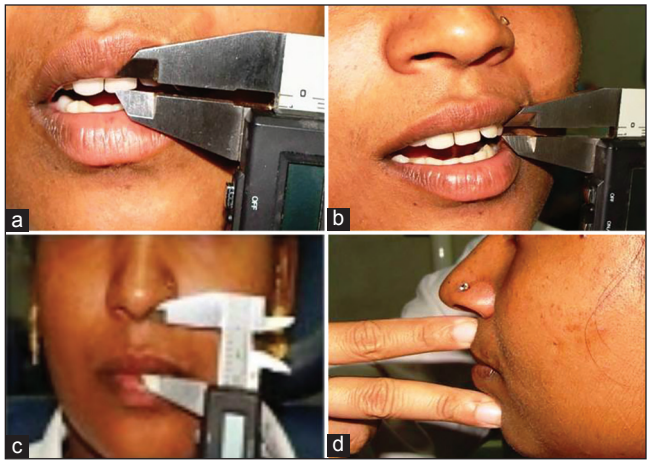

Figure 1: (a) Distance between maxillary lip at rest to left maxillary central incisor measured. (b) Distance between maxillary lip at rest and left maxillary canine measured. (c) Maxillary lip length measured. (d) Assessment of anteroposterior skeletal relation

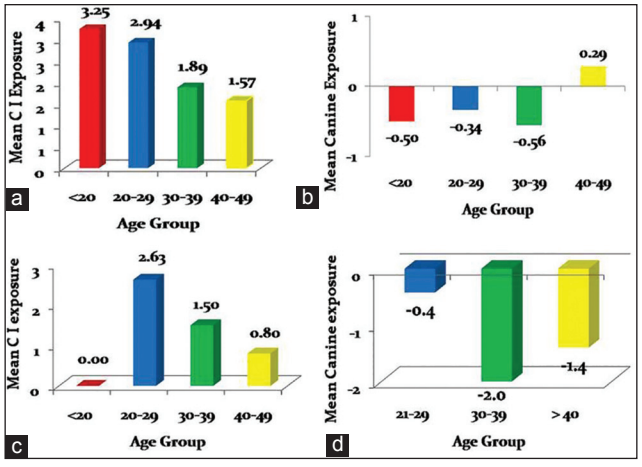

Figure 2: (a) Mean central incisor (CI) exposure versus age in females. (b) Mean canine exposure versus age in females. (c) Mean CI exposure versus age in males. (d) Mean canine exposure versus age in males

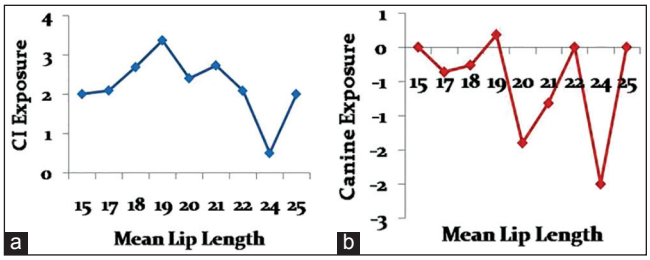

Figure 3: (a) Central incisor exposure versus mean lip length. (b) Canine exposure versus mean lip length

anterior teeth can contribute to discrepancies in the occlusal plane, occlusal vertical dimension and occlusal scheme. Various guidelines have been suggested by various authors.[1-8] Misch[9] suggested the maxillary canine as a reliable guideline as opposed to the maxillary CI in determining the vertical relation of the maxillary anterior teeth. The measurements recorded were average means of a single parameter; evaluating the range of exposure of the incisor edge and cusp tip of the maxillary CI and maxillary canine to the lip at repose. This hypotheses were further analyzed to evaluate the relationship of the incisal edge exposures of the maxillary CI and maxillary canine to the maxillary lip at rest, to the maxillary lip length, and the influence of incisal wear and anteroposterior skeletal relation to exposure of the incisal edges.

Analyzing the relationship of the incisal edge exposures of maxillary CI and canine to the maxillary lip at rest, it was observed that 93% of male subjects displayed 0-5 mm of CI exposure and 94% of female subjects displayed 0-5 mm of CI exposure. On the contrary, 80% of male subjects displayed − 2-2 mm of canine exposure and 91% of female subjects displayed − 2-2 mm of canine exposure to the maxillary lip at rest. The exposures of the maxillary CIs were 2-3 mm longer than the canines in reference to the horizontal plane in both the genders. The results obtained supports similar findings conducted by Misch[10] and Patel *et al*.[11] Considering the narrow range of visibility of the canines, it can be inferred that the occlusal plane can be established by positioning the canines first. The influence of soft tissue contours, size, lip line, smile line, midline, and incisal edges must also be in harmony with the amount of tooth display.

The perioral musculature can be classified based on their insertion into three groups. The first group of muscles comprise of the orbicularis oris, buccinator, levator anguli oris, depressor anguli oris, zygomaticus major and risorius. These muscles insert into the modiolus that is a tendinous thickening at each commisure. The second group of muscles comprises of levator labii superioris, levator labii superioris alaeque nasi and zygomaticus

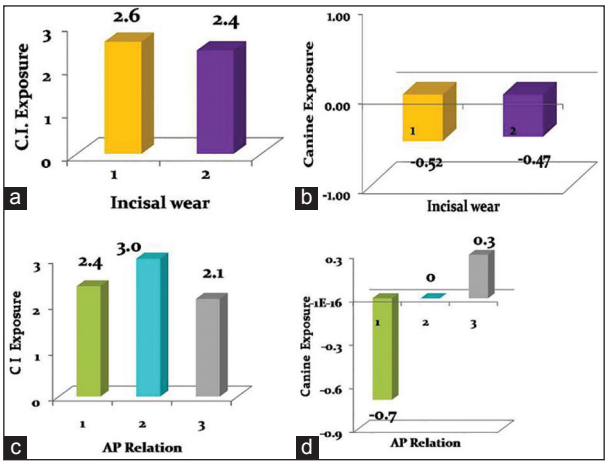

Figure 4: (a) Central incisor (CI) exposure versus incisal wear. (b) Canine exposure versus incisal wear. (c) CI exposure versus AP relation. (d) Canine exposure versus AP relation

minor. These insert into the upper lip. A third group of muscles comprises of depressor labii inferioris, mentalis and platysma. These insert into the lower lip. The tonicity and positions of these muscles determine the amount of visibility of the anterior teeth, and they vary with individuals.[15] Using soft tissue cephalometric landmarks, the vertical distance between the soft tissue subnasale and the stomion superius was calculated as the maxillary lip length. It was observed that with respect to the mean lip length of each age bracket and gender, CI exposure averaged 1-3 mm and canine exposure averaged − 1-0 mm. With the increase in lip length, tooth exposure decreased. Short lips displayed increased tooth display. Fudalej[16] in his study on the long term changes of the upper lip position relative to the incisal edge observed a continuous elongation of the upper lip throughout life as a result of postadolescent facial growth. During the 2nd and 3rd decades of life, facial growth balanced lip elongation. As the age advanced minimal facial growth lead to a decreased incisal exposure. Sackstein[17] observed a decreased anterior tooth display with age and greater in women than men.

Incisal attrition is multifactorial and can be related to age, occlusal factors, acidity, genetics or trauma. It can break through the enamel to the dentin and even cause pulpal exposure. The extent and severity of incisal attrition were assessed using the TWI by Smith and Knight. CI exposure averaged 0-3 mm and canine exposures averaged − 1-1 mm. CI and canine incisal edge exposures decreased with an increased incisal wear. Oltramari-Navarro *et al*.[18] in their investigation on tooth wear patterns in adolescents with normal occlusion and Class II Division 2 malocclusion too observed greater tooth wear on the incisal surfaces of maxillary lateral incisors and maxillary canines in a normal

occlusal group. He attributed this pattern of wear to the different interocclusal arrangements.

Edward H Angle emphasized the importance of soft tissue profile. He designated the three main classes of anteroposterior skeletal relationships as Class I or normognathic, Class II or retrognathic and Class III or prognathic. Analyzing the relationship of the anteroposterior skeletal ralation to the tooth display of incisal edges, it was observed that Class II and Class I skeletal relation observed an increased CI exposure of 3 mm and 2.4 mm respectively compared to Class III (2.125 mm). Increased canine exposures were observed for Class III (0.3 mm) and Class II (0 mm) compared to Class I (−0.7 mm). Class II skeletal relation depicted narrow range of exposures for CI and Class I for canines. The facial profile, lip length, incisal attrition and occlusal patterns could serve as influential factors.

Within the scope and limitations of this pilot study, descriptive analysis demonstrated a linear favorable relationship of the canine to the CI. The maxillary canine incisal tip position described more consistent values within a narrow range to the maxillary lip at rest with respect to age, gender, lip length, incisal wear and skeletal relation. Pearson's correlative analysis demonstrated a highly significant positive correlation of canine over CI with borderline significance of anteroposterior relationship. It can be inferred that along with the other guidelines used in establishing the vertical positions of the maxillary anterior teeth, maxillary canines could also serve as a potential determinant.

Limitations of this study include investigator variability, limited sample size and the use of a manual vernier caliper for measurements. In samples with a negative exposure, slight distortion of the lip was required to take the measurements. Positive studies are available on the influence of lip length, age and gender to the incisal exposure, but further studies involving a larger sample size and the effects of other parameters are mandated.

Conclusion

The vertical positioning of the maxillary anterior teeth play a major role in determining the anterior guidance, phonetics and esthetics. In order to obtain pleasing esthetics, the degree of tooth visibility must be in harmony with the other esthetic determinants such as incisal edges, occlusal plane, lip line, smile line, contours and midline. It must not be considered as an independent entity.

Within the scope and limitations of this pilot study, it was observed that the incisal edge of the maxillary canines exhibited a narrow range of exposure to the maxillary lip at rest. It can be inferred that along with the other guidelines used in establishing the vertical positions of the maxillary anterior teeth, maxillary canine can also serve as a guideline in establishing the maxillary occlusal plane.

Clinical implications

Considering the parameters investigated, descriptive and correlative analysis demonstrated a favorable response of the maxillary canine over the maxillary CI. It can be inferred that along with the other guidelines used in establishing the vertical positions of the maxillary anterior teeth and occlusal plane, the position of the maxillary canine could serve as a potential and reliable determinant.

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