EVALUATION OF THE NOSTRIL SHAPE IN SKELETAL CLASS I, CLASS II AND CLASS III PATIENTS WITH MAXILLARY DISCREPANCY: AN INVIVO STUDY

By

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ABSTRACT

Nose dominates the middle portion of the face and is in close harmony with lips and chin. It is considered as the keystone of facial esthetics. Since the growth of the nose is closely related to that of the maxilla, there can be a correlation between nostril and maxillary skeletal pattern. This study was designed to identify the relation between sagittal maxillary skeletal pattern and nostril, using photographs.

Background & Objectives:

- To compare the relationship between maxillary size and nostril shape in patients with skeletal class I, skeletal class II with prognathic maxilla and skeletal class III with retrognathic maxilla.
- To find whether there are any significant changes in the values of nostril inclination of patients in different skeletal problems.

Materials and Methods:

62 patients with skeletal Class I, 62 patients with skeletal Class II due to prognathic maxilla and 62 patients with skeletal Class III due to retrognathic maxilla were collected from Department of Orthodontics and Dentofacial Orthopedics, St. Gregorios Dental College, Chelad, Kothamangalam. Photographs of these patients were taken which included profile view and basal view, and were digitalized using Image J software. Inclination of nostril was measured and classified using modified Topinard system classification.

Results and Conclusion:

Most common type of nostril found in Class I skeletal pattern was Type III. In Class II skeletal pattern due to prognathic maxilla, most common type nostril was Type II, whereas in Class III retrognathic maxilla, it was Type V. The study concludes that there is a significant correlation between nostril and maxillary skeletal pattern.

Keywords:

Inclination of nostril, maxillary skeletal pattern, Profile and basal photograph, Image J software, Classification of nostril

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Introduction

INTRODUCTION

One of the most important components of orthodontic diagnosis and treatment planning is the evaluation of the patients' soft tissue.[1,72] Subtelny[2], Burstone[3], and Bowker et al.[4] have recommended that the analysis of the soft tissue should be done carefully for the proper evaluation of an underlying skeletal discrepancy because of individual differences in soft tissue thickness.[72]

Nose dominates the middle portion of the face and is in close harmony with lips and chin.[71] Nose is considered by some clinicians as the keystone of facial esthetics.[9] This view is supported by Czarnecki, Nanda, and Currier,[10] who reported that the perception of facial appearance is greatly determined by the nasal form and its association with other parts of the face.[77]

The nose has a pyramidal shape. It can be visually delineated into two parts – the body and the tip. As described by Burget and Menick[91], the nose possesses nine distinct esthetic subunits, including the dorsum, tip, columella, paired sidewalls, alae, and soft triangles. The upper third consists of the bony pyramid, made up of the nasal bones. The paired upper lateral cartilages insert just under the caudal (lower) end of the nasal bones and their fusion with the midline cartilaginous septum in a "T" type configuration forms the middle third ("vault"). The lower third of the nose consists of lower lateral cartilages.

Angle[27] emphasized that if the dentition is arranged in optimum occlusion and is perfectly intact, the soft tissue would then assume a harmonious position.[77] However, Hellman[28] contradicted this by saying that variations from normal may occur in soft tissue despite the presence of a normal occlusion.[77] Further, Czarnecki et al[10] concluded that the nose lip–chin relationship is exceedingly significant in the determination of facial aesthetics.[77] Therefore, nasal form and its relationship to the other facial structures play an important role in the assessment of patient's facial balance before orthognathic surgery,[7,8] rhinoplasty,[6] and other orthodontic procedures.[69]

For an aesthetic face, the nose should be in balance with the upper and lower third of the face and with horizontal facial proportions. The nose should be examined in the frontal, lateral, oblique and basal views. Symmetry of the nose, nasal tip projection (Ratio between nasal projection and nasal length is 0.55-0.66:1) , nasal tip projection to the upper lip position (About 50 to 60% of the tip should lie anterior to a vertical line drawn adjacent to the most projecting part of the upper lip and can also be measured as 0.67 times the ideal nasal length), nasofrontal angle (Angle between the line from the glabella to the nasion and the line from the nasion to the tip), the shape of the nasal dorsum (normal, convex, concave), the shape of the nasal tip (straight, upturned or downturned), nasal index (the ratio of the widest part of the nose to its length multiplied by 100), supra tip break and nasal base inclination (normal, downturned or upturned) should be examined before orthodontic and orthognathic treatment planning. The ideal nasal proportion includes a straight nasal dorsum, with the nasal-tip cartilage and dorsal cartilage above the nasal tip creating the supra tip break and the alar rims 1 to 2 mm superior to the columella when observed in a lateral view. Nevertheless, nasal features vary from race to race, along with many other facial characteristics.[77]

The growth of the nasal cartilage is related to the growth of the middle third of the face. Embryologically, the nose originates from the frontonasal prominence, developed by the local thickenings of surface ectoderm.[75] The maxillary prominence, a tissue of mesodermal origin, derives from the first brachial arch.[75] These two structures are closely related to each other and the development of the nose is completed by the fusion of the frontonasal and maxillary processes.[75] So, growth of nose may relate to growth of maxilla.

Scott[18] suggested that the cartilaginous nasal septum is a primary growth center that pushes and thrusts the midface downwards and forward.[71] Although this hypothesis is not unanimously accepted, numerous authors[19-22] have shown that prenatal and/or postnatal impaired growth of the nasal septum due to genetic or traumatic etiology causes maxillary hypoplasia in the sagittal dimension.[71]

Nasal growth proceeds at a relatively constant rate into adolescence and is almost completed by the age of 16 in girls and 18 in boys.[11-15,71] Subtelny[2] found that soft tissue nose continues to grow in a downward and forward direction from 1 to 18 years of age. However, vertical growth of the facial skeleton continues well after puberty both in males and females, even after the completion of growth in the sagittal and transverse dimensions.[16,71] The relationship between nasal morphology and the facial skeletal pattern has received great attention in the orthodontic literature.[17,5,71]

The growth of the nose is closely related to that of the maxilla in antero-posterior direction and the inclination of the maxilla.[70] The vertical position of the maxilla also affects the nasal parameters.[70] Nehra et al[23] found out that there is a significant correlation between vertical maxillary skeletal pattern and soft tissue nasal parameters. The nasal length was significantly correlated with upper anterior facial height and an inclination of the palatal plane.[70] Upward nasal tip inclination showed a significant negative correlation with inclination of the palatal plane.[70] Prasad et al[62] found out that long nose with increased nasal prominence were seen with increase in the anteroposterior length and vertical height of maxilla. Nose projection affects prognathism and retrognathism of the jaw, making it an important factor in planning and predicting outcomes of orthognathic surgery. Buschang[17] said that horizontal growth of nose is associated with horizontal growth of maxilla. The configuration of the dorsum of the nose in Class II subjects followed the general convexity of the Class II face.[13] The Class I subjects tended to have straighter noses, and the Class III subjects revealed a concave configuration of the nose along the dorsum.[13]

Soft tissue changes of the nose are seen after maxillary osteotomies.[80] Alar widening may be favorable in a person with vertical maxillary hyperplasia and thin slit like nares.[80] Rosen[38] observed that alar rim width increases with anterior and/or superior repositioning of the maxilla. Dantas et al.[85] concluded that surgeries of maxillary advancement and superior reposition tend to cause elevation and advancement of the nasal tip, as well as enlargement of the nasal base. A wide alar base and an obtuse nasolabial angle can be partially controlled by soft tissue techniques such as an alar base cinch, V-Y closure of the lip and reapproximation of the facial muscles.[80] Septoplasties and rhinoplasties have, in part, been performed during LeFort I osteotomies.[80] Examination of the nose and knowing the ideal proportion is important for the treatment planning for orthognathic surgery.

The nasal base view is important for overall appearance and balance of the nose and is one of the several nasal features that must be optimized during rhinoplasty.[24] The nasal base, also known as alar-columellar complex, consists of the ala and the alar base, columella, nostrils, and lobule.[25] From the basal view the size of the nostrils and degree of flaring can be assessed. Vertical lines passing through the alar facial groove can be drawn in the basal view. Excess alar side wall lateral to this line gives an objective measurement of the degree of alar flaring. Ideal nostril–tip relationship should be approximately 2:1 on the basal view. The aesthetically acceptable nostril shape is said to be teardrop-shaped, with a long axis from its base to the apex oriented in a slightly medial direction.[26]

For a balanced face, the skeletal base should be in a favorable position. Face is composed of a cranial base, maxillary base and mandibular base. According to the relation between maxillary and mandibular skeletal base, the skeletal pattern is divided into Class I skeletal pattern, Class II skeletal pattern and Class III skeletal pattern.

In Class I skeletal base, maxillary and mandibular skeletal base will be in ideal relation. Diagnosis of skeletal relation should be based on lateral cephalogram and clinical examination. Clinically these patients will have straight profile, orthognathic divergence and slightly negative lip step. Cheekbone-nasal base-lip contour line curves ideally without interruption in skeletal Class I relation.

In Class II skeletal malocclusion there is an anteroposterior disproportion in size or discrepancy in the position of the jaws. Clinically these patients have convex profile, posterior divergence, lip incompetence, hyperactive mentalis and deep mentolabial sulcus in case of increased overjet due to dental Class II and negative lip step. Skeletal Class II malocclusions can be classified as those with either mandibular deficiency, maxillary excess or a combination.

In skeletal Class II relationship due to mandibular deficiency, the mandible will be small or retruded relative to the maxilla and have a posterior divergent face. Mandibular deficiency in cephalometric analysis is exhibited as an increased ANB angle, a normal SNA angle with a decreased SNB angle, increased A-B difference in WITS analysis, average effective maxillary length, decreased effective mandibular length and normal position of point A but a posterior position of point B relative to Nasion perpendicular.

Skeletal Class II due to maxillary excess may present as overdevelopment in the vertical or anteroposterior dimension or both. With vertical maxillary excess, the mandible may be of normal size but in a retrusive position because of the inferior position of the maxilla. Maxillary excess in cephalometric analysis is exhibited as an increased ANB angle, an increased SNA angle with a normal SNB angle, increased A-B difference in WITS analysis, increased effective maxillary length, average effective mandibular length and normal position of point A but a posterior position of point B relative to Nasion perpendicular.

Individuals with skeletal Class III malocclusion may have retrognathic maxilla, prognathic mandible or a combination. Clinically these patients present with concave profile, anterior divergence, positive lip step and break in the cheekbone-nasal base-lip contour line. Maxillary deficient patients exhibit malar deficiency, flattening of the midface and increased scleral show. In maxillary deficiency patients, cephalometric values show decreased or negative ANB angle, a decreased SNA angle with a normal SNB angle, decreased A-B difference in WITS analysis, decreased effective maxillary length, average effective mandibular length and posterior position of point A but a normal position of point B relative to Nasion perpendicular.

Cephalometric values of skeletal Class III due to mandibular prognathism show decreased ANB angle, a normal SNA angle with an increased

SNB angle, decreased A-B difference in WITS analysis, average effective maxillary length, increased effective mandibular length and normal position of point A but an anterior position of point B relative to Nasion perpendicular.

Since the growth of the nose is closely related to that of the maxilla, there can be a correlation between nostril and maxillary skeletal pattern. Currently no material is available in literature which elaborates the relation between nostril and maxillary skeletal pattern. In an attempt to fill this lacuna and get a more thorough understanding of nostril shape in different maxillary skeletal pattern, this study was undertaken.

This is a photographic study. Analysis was carried out using Image J software. Image J is an open-source image analysis software platform that has aided researchers with a variety of image analysis applications, driven mainly by engaged and collaborative user and developer communities.[95] The close collaboration between programmers and users has resulted in adaptations to accommodate new challenges in image analysis that address the needs of Image J's diverse user base.[95]

Nasal measurements can be used for comparing various treatment outcomes, treatment planning, and nasal surgeries. Finding the relation between maxilla and nostrils will help us to diagnose skeletal problems and to confirm whether the problem lies in maxilla or mandible. It will also help the plastic surgeons to find the normal inclination of nostril for their facial profile.

Aim & Objectives

AIM OF THE STUDY

To find the relation between maxillary size and nostril shape in skeletal class I, class II and class III patients.

OBJECTIVES OF THE STUDY

1. To compare the relationship between maxillary size and nostril shape in patients with skeletal class I, skeletal class II with prognathic maxilla and skeletal class III with retrognathic maxilla.

2 To find whether there are any significant changes in the values of nostril inclination of patients in different skeletal problems.

Background &
Review of literature

BACKGROUND OF THE STUDY

Facial harmony in orthodontics is determined by morphologic relationships and proportions of the nose, lips, and chin.[72] The balance among these three anatomic structures can be altered by both growth and orthodontic treatment.[72] The nose plays a dominant role in facial aesthetics because of its location exactly in the middle of the face.[71] Its importance is demonstrated by remarkable enhancement in facial aesthetics of a patient who has had minor rhinoplasty procedures.[72] There appears to be an association between nasal morphology and growth of the maxilla.

Base of the nose contain ala, columella and nostrils. Knowing the relation between nostril and maxilla will help in diagnosis and treatment planning. It can be used for the treatment planning in orthodontics as well as orthognathic surgery.

REVIEW OF LITERATURE

In 1959 Subtelny[2] conducted a longitudinal study on soft tissue facial structures and their profile characteristics in relation to underlying skeletal structures. They found that soft tissue nose continues to grow in a downward and forward direction from 1 to 18 years of age. Lip posture is closely related to underlying structures, the teeth and alveolar processes.

In 1967 Posen[12] conducted a longitudinal study on the growth of the nose and found that after the age of 14 years the nose tip did not grow forward to the same extent as did the nasal bones. Nasal growth changes in both size and form were significant after the age of 13 years. The nose tip became more prominent within the total facial profile after 2 to 3 years of age in both groups.

In 1969 Chaconas[13] conducted a cephalometric investigation to evaluate the growth of the nose and its relationship to various morphogenetic dentoskeletal criteria, age, and sex. The results showed that the growth in length of the nasal bones had taken place prior to the age of 10 years but that the soft-tissue nose grew downward and forward with the maxillary complex. The configuration of the dorsum of the nose in Class II subjects followed the general convexity of the Class II face. The Class I subjects tended to have straighter noses, and the Class III subjects revealed a concave configuration of the nose along the dorsum.

In 1969 Clements[29] conducted a study on Nasal imbalance and the orthodontic patient and concluded that Nasal growth occurred in all patients during orthodontic therapy and Nasal imbalance was intensified during orthodontic treatment.

In 1971 Farkas and Lindsay[30] modified Topinard classification of nostril by adding Type VII

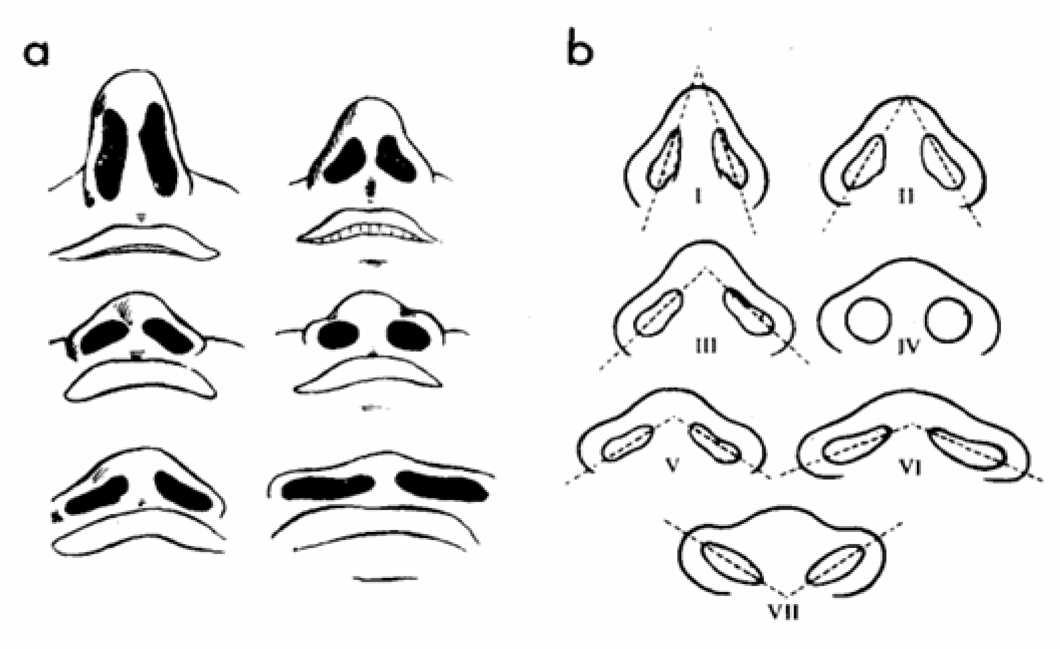


Figure 1: Nostril Types

A – The six nostril types of Topinard

B – The seven nostril types of Farkas et al

In 1975 Wisth[31] conducted a study on Nose morphology in individuals with Angle Class I, Class II or Class III occlusions. He concluded that the inclination of the nose in relation to the nasion-sella-line was similar in all groups, and so was the nose length as well. The depth of the nose, when related to the hard and soft tissue facial planes was, however, significantly different, apparently due to the different sagittal position of the chin.

In 1980 Millard[84] introduced alar cinch for flared nose in cleft patients. In this technique the alar flaps are cinched to each other and to the base of the septum with one or more permanent sutures.

In 1981 Radney and Jacobs[81] evaluated the soft-tissue profile response to total surgical maxillary intrusion. Statistical analysis of soft-tissue behavior of the nose, upper lip, lower lip, and chin was performed. The results showed that the nasal tip (Pn) moved slightly superiorly with maxillary intrusion and advanced slightly with a combination of maxillary intrusion and protraction. The nasal tip moved superiorly 1 mm for every 6 mm of superior movement of Z point. As the maxilla was intruded and retracted, the soft-tissue points LS, SLS, and Sn retracted in an 0.70, 0.30, and 0.30 ratio respectively with 1mm retraction. the nasolabial angle increased only with intrusion and retraction of the maxilla. With intrusion alone and intrusion with protraction, the nasolabial angle was relatively unchanged. They concluded that the nasolabial angle changed in response to the direction and amount of maxillary intrusion. The upper lip (LS, SLS, Sn) responded variably to the direction and amount of maxillary intrusion. The lower border of the upper lip (Sto) moved superiorly with intrusion of the maxilla. The soft-tissue chin (ILS, PgS) responded to posterior maxillary intrusion by autorotating on the same arc as the bony chin on a 1: 1 basis. They also concluded that the nasal tip (Pn) moved superiorly slightly with maxillary intrusion and pro- traction.

In 1982 Collins and Epker[32] introduced simultaneous alar base cinch suture with total maxillary surgery to prevent alar base flaring. The advantage of this technique is to avoid skin incisions since it is readily accomplished through the circumvestibular incision used for the maxillary surgery.

In 1983 Farkas et al.[33] assessed the standard nostril types. Nostril type was assigned according to the inclination of the medial longitudinal axis of the nostrils, generally following the Topinard system in a group of randomly selected, healthy young North Americans. They found that the most common nares were Type II in Caucasians (52.8%), Type III in Asians (52.8%), and Type VI in blacks (50.0%). Specific columellar and alar base configurations were associated with many nostril types.

In 1983 D. Mahler et al.[34] introduced a measuring scale for evaluation of the nasal shape. He said that using a graphic scale of 4 aspects of the nose--length, width, hump, and tip--can enable almost anyone to achieve a more or less objective evaluation of nasal characteristics. The scale ranges from 1, being the "nicest," to 7, being the "worst." The scales can be prepared on translucent sheets suitable for superimposing on pre- and postoperative photographs, and the differences in scores give a value to the result.

In 1983 Mansour et al.[35] evaluated soft tissue changes resulting from Le Fort I maxillary surgery. They concluded that with advancement of maxilla there is progressive increase in the horizontal soft-tissue movement from the tip of the nose to the free end of the upper lip.

In 1985 Burget and Menick[91] stated that the nasal surface is made up of several concave and convex surfaces separated from one another by ridges and valleys. These smaller parts (tip, dorsum, sidewalls, alar lobules, and soft triangles) may be called topographic subunits. Using this subunit approach to nasal repair, scars can be positioned within the contours of the nasal surface and preference should be given to complete subunit resurfacing.

In 1986 Robison et al.[36] evaluated the relationship of skeletal facial pattern and soft-tissue nasal form using cephalometric radiographs, posteroanterior radiographs, and the physio print photographs. They found that more than 86% of patients demonstrated a correlation of nasal shapes with specific skeletal groupings. They noted that patients with straight profiles tended to have straight noses; convex profiles accompanied convex nasal shapes; and concave profiles were found with concave nasal shapes.

In 1986 Farkas et al.[37] conducted a morphometric study of nose. They found that in Asians and blacks with type IV nostrils, the nasal tip protrusion was smaller and the columella shorter than in Caucasians with type III. The nose width did not differ greatly but the columella was narrower than in Caucasians with type II nostrils. The columella and the nose width were significantly greater in type VI noses and the columella and tip protrusion were nonsignificantly greater.

In 1988 Rosen[38] studied lip and nasal aesthetics following Le Fort I osteotomy. Study was conducted on forty-one patients undergoing Le Fort I osteotomy for superior and/or anterior repositioning of the maxilla. It was observed that alar rim width increases with anterior and/or superior repositioning of the maxilla, but increase in nasal tip projection occur only when there is an anterior vector of maxillary movement. Horizontal displacement of the upper lip at the vermilion border was 0.82 +/- 0.13 mm for every 1 mm of maxillary advancement at the incisal edge and 0.51 +/- 0.13 at the subnasale for every 1 mm of maxillary advancement at point A. Eighty percent of patients undergoing maxillary intrusive procedures had lip shortening ranging from 20 to 50 percent of the vertical maxillary reduction.

In 1988 Meng et al.[11] evaluated growth changes in the nasal profile from 7 to 18 years of age using lateral cephalogram and found increments in nose height, depth, and inclination are essentially complete in girls by 16 years of age, while continuing to increase in males up to and beyond 18 years. They also found that the ratio of ‘nose depth to sagittal depth of the underlying skeleton changed from 1 :2 at 7 years in both sexes to 1: 1.5 in male subjects and 1: 1.6 in female subjects at 18 years.

In 1988 Waite et al.[80] studied 22 patients who had undergone simultaneous rhinoplasties and orthognathic surgeries. A general post-operative esthetic impression was made by the surgeon using subjective facial harmony methods. A post-operative questionnaire was also completed by the patient. The results showed that subjective esthetics, as viewed by the surgeon, were felt to be favorable in most subjects. 2 patients had a nonsignificant change. Patient survey showed that 82% were pleased with their rhinoplastic result. 94% of patients were pleased with their jaw surgery and thought it best to have both procedures done simultaneously. Only 16% would have considered isolated nasal surgery.

In 1989 Burke and Hughes-Lawson[39] conducted a Stereo photogrammetric study of growth and development of the nose. Various nasal parameters were measured to study growth apart from dorsum of the nose between 9 and 11 years of age, all linear parameters were larger for boys by an amount increasing with age. The early growth in girls and late growth in boys suggested the presence of an adolescent growth spurt in the nose, which was confirmed by volumetric measurements. Developmentally the greatest change occurred in anteroposterior prominence of nasal tip in both sexes and the least change occurred in intercanthal width.

In 1990 Genecov et al.[14] studied cephalometric radiographs of 64 untreated persons (32 Class I and 32 Class Il) to determine the amount, direction and timing of facial soft tissue development. They found that antero-posterior growth and increased anterior projection of the nose continued in both males and females after skeletal growth had subsided and the angular shapes and positional relationships of the nose, lips and chin remained relatively constant throughout the development. No relationships were found between the amount of nasal development and skeletal class or sex of the subjects.

In 1991 Ohki et al.[40] studied the racial difference on dimensions and resistances of the human nose. Statistically significant variation between racial groups was found in nasal width and the differential between dorsi-ventral and transverse nostril diameters. Corresponding differences were also found in nasal airflow resistances of combined and separate nasal cavities in both the untreated and decongested state. Caucasian noses were leptorrhine, Negro noses were platyrrhine, and Oriental noses were of intermediate dimension.

In 1991 Grymer et al.[21] conducted a study to evaluate the total nasal resistance (TR) on the development of the nasomaxillary complex. The study was conducted on 42 identical twins. Comparison within and between twins with different septal deformities indicated that the cartilaginous nasal septum influences the development of the nose and the anteroposterior dimensions of the maxilla. Anterior septal deformities resulted in underdeveloped cartilaginous noses and a shorter anteroposterior dimension for the maxilla. No relation was found with regard to posterior septal deformities, which may be considered as part of the development of the midface. Vertical dimensions of the face were related to TR. Increased values of TR were significantly related to a shorter maxillary height.

In 1992 Buschang[17] conducted a cephalometric study to evaluate horizontal growth of soft tissue nose relative to maxillary growth in girls age 6 to 14. cephalometric radiographs were taken at ages 6, 10, and 14, superimposed and evaluated horizontal growth changes of two soft-tissue landmarks (subnasale and pronasale) and two skeletal landmarks (anterior nasal spine and A point). They concluded that horizontal growth at Pr and Sn is closely associated with horizontal growth at ANS and A point.

In 1992 Fitzgerald[41] evaluated the relative inclination of the lower border of the nose and the upper lip, as well as their relationship to each other. No statistically significant difference was demonstrated between the values for men and women in this study, but the women did have a slightly larger nasolabial angle. A linear comparison of the three nasolabial parameters with six skeletal measurements revealed no significant relationship between the soft tissue profile of the nasolabial region and the underlying skeletal relationships.

In 1993 Ofodile et al.[42] conducted a study on black American nose. 201 black American noses were divided into three groups, i.e., Groups A, B, and C, which we have called the "African," the "Afro-Caucasian," and the "Afro-Indian." This study shows that Fifty-three percent of the African noses had a concave dorsum, whereas only 10% of the Afro-Caucasian and 8% of the Afro-Indian group had a concave dorsum. The most common nostril types were type IV (20%), type V (27%), and type VI (25%), the distribution of which varied with the nasal type. Anthropometric measurements showed variations according to type, with the African noses being the shortest and widest, the Afro-Caucasian the narrowest, and the Afro-Indian being the longest.

In 1993 Buschang et al.[15] conducted a study on longitudinal shape changes of the nasal dorsum. The results showed that changes in the nasal dorsum are most closely related to angulation changes of the lower dorsum, particularly during adolescence. The lower dorsum rotates downward and backward in persons who show greater vertical and less horizontal growth changes. Rotational changes of the lower dorsum are most closely related with vertical changes at pronasale.

In 1993 Cottrell and Wolford[86] presented a paper to discuss a general approach to combine orthognathic and rhinoplastic treatment planning. The advantages and disadvantages of combined orthognathic and rhinoplastic surgery were discussed and guidelines for performing combined surgery were given.

In 1994 Hui et al.[43] conducted a retrospective study of 25 patients with unilateral cleft lip and palate and 25 patients with hypoplastic maxillae without a cleft to evaluate the soft tissue changes following maxillary osteotomies. It was concluded that in maxillary osteotomy, the cleft group showed a higher soft tissue to hard tissue movement ratio. The correlation between soft and hard tissue movements were more statistically significant in the cleft group than in the non-cleft group.

In 1995 Morgan et al.[44] conducted a study to find the racial differences in nasal fossa dimensions determined by acoustic rhinometry. The main parameters analyzed were minimal cross-sectional area (MCA), the distance at which this occurred (D), nasal volume at 0-4 cm (Vol), mean cross-sectional area at 0-6 cm (MA), and the cross-sectional area at 10 points in the nose (0, 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, and 6 cm) analyzed as a series. There were significant racial differences in volume in both decongested and non-decongested noses. In the non-decongested state mean cross sectional area was significantly different in all racial groups. In the decongested state there was a significant difference between Negroes and the other two groups and Orientals and Caucasians were a homogenous population. They concluded that race has a significant effect on acoustic rhinometry measurements.

In 1995 Begg and Harkness[6] conducted a study to establish a set of standard values for the form of the nose and its relationship to other craniofacial structures in young adult Caucasians. They found that the men had significantly longer and straighter noses than the women, and their noses also projected further from the face. The dorsum of the nose was straight in most subjects. The vertical distances from the tip of the nose to the most prominent part of the upper lip, to the incisal edge of the maxillary central incisor, and to soft tissue pogonion were significantly greater in the men. There were no gender differences in the horizontal distances between the same points and the tip of the nose. Subnasale was significantly more prominent in the men.

In 1996 Milgrim et al.[45] conducted a study on Anthropometric Analysis of the Female Latino Nose. They concluded that Latino noses can be anthropometrically categorized as mesorrhine.

In 1997 W. Dawei et al.[46] studied the Differences in Horizontal, Neoclassical Facial Canons in Chinese (Han) and North American Caucasian Populations. They found that the nose width corresponded to one-quarter of the face width (the nasofacial canon) significantly more frequently in Chinese participants (51.5%) than in Caucasian adults (36.9%). The nose was narrower than one-quarter of the face width in 38.8% of North American Caucasians and in 21.8% of Chinese. In defiance of the naso-oral canon, the mouths of Chinese people were significantly more often narrower than 1.5 times the nose width (71.8%), while in North American Caucasian ethnics the mouth was significantly more frequently wider (60.2%).

In 1997 Ferrario et al.[47] conducted a study on Three-dimensional study of growth and development of the nose to describe normal nasal growth in a large sample of boys and girls from 6 to 14 years of age, to compare nasal development at 14 years of age with its adult dimensions, and to evaluate differences in growth patterns between males and females. The results showed that volume, surface, and linear distances were larger in males than in females, with the exception of the 11-to-12 age group, where a sharp female growth spurt was present. In males, the growth spurt was broader, and continued to 13 years of age at a nearly steady rate.

Statistically significant gender differences could be found both in the adult group and before the adolescent growth spurt.

In 2000 Aung et al.[48] conducted a three-dimensional laser scan assessment of the oriental nose with a new classification of Oriental nasal types. Depending on the fullness and roundness of the nasal tip and the prominence of the alar lobules on either side, three distinct shapes have been identified. They have been classified into types A, B and C where type A has a very prominent alar lobule and a full and rounded nasal tip. In type B, the alar lobule was less prominent and the nasal tip was more defined while in type C the alar lobule was the least prominent resulting in the lateral walls forming a relatively straight slope from the tip to the alar base.

In 2000 Mommaerts et al.[49] studied the nasal profile changes after maxillary impaction and advancement surgery. The results showed there was no difference in nasal tip elevation and change in nasal tip projection between the 2 groups. A linear correlation with a weak clinical relevance could be demonstrated between nasal tip projection and maxillary advancement in the group that was treated without sub spinal osteotomy. Palatal plane rotation had a significant influence on nasal tip projection but not on tip elevation in both groups. They concluded that the advancing piriform aperture pushing on the alae, and not the nasal spine, is responsible for the increase in nasal tip projection. The sub spinal osteotomy is not superior to the conventional Le Fort I-type osteotomy in regard to minimizing nasal tip changes and obtaining control over the columello-labial angle.

In 2003 Porter et al.[50] conducted a study to analyze the African American female nose using anthropometric measurements. They found that African American woman has a columellar to lobule ratio of 1.5:1, a nasolabial angle of 86 degrees, and an alar width to intercanthal distance ratio of 5:4. The degree of variability found within this group of young African American women is nose width-nose height index mean, 79.7 (range, 57 to 102); nasal tip protrusion-nose height index mean, 33.8 (range, 23 to 46); and nasal tip protrusion-nose width index mean, 42.8 (range, 32 to 61).

In 2003 P. Fernández-Riveiro et al.[51] conducted a photogrammetric study to obtain objective average measurements of the soft tissue facial profile to use them as a guide for aesthetic treatment goals. The results showed that sexual dimorphism was found for several angles: nasofrontal, vertical nasal, nasal, nasal dorsum, and mandibular contour. Wide individual variations in nasolabial and mentolabial angles were also observed.

In 2003 Hwang and Kang[96] conducted a study to investigate morphological characteristics of Korean noses, nasal bases and nostrils were measured and classified in Korean adults. The height and the width of the nasal base, the height and the width of the columella, the length of the long and short nostril axes, and nasal alar angle were measured. The shapes of the nostrils were classified into 7 types by the angle between the right and left long axes of the nostrils. The study showed that the angle was 84.8 + 24.5 ° in males, or 76.9 + 18.3 ° in females.

In 2004 Leong et al.[52] compared the aesthetic proportions between the Oriental and Caucasian nose. They concluded that when compared with the Oriental nose the Caucasian nose is more greatly projected at tip and nasion. The Oriental nose is wider at alar base but not at bony base. The naso-labial angle in Oriental males is not less acute than Caucasians because of forward projection of the upper lip. The nasofrontal and nasofacial angles do not appear to vary significantly.

In 2006 Gulsen et al.[5] conducted a study to evaluate the relationship between the facial skeletal and the nasal profile in Anatolian Turkish adults. He measured fifteen facial skeletal parameters and 12 nasal parameters (10 soft tissue and 2 nasal skeletal) on lateral cephalograms. He concluded that nasal length, prominence, and form are associated with height and length of the maxilla and the mandible. Posterior-inferior development of the face results in a convex nasal profile, whereas anterior development produces a straight or concave nasal profile.

In 2006 A. Uzun et al.[53] studied the average values of the nasal anthropometric measurements in 108 young Turkish males. Results showed that the mean total length and nasal bridge length of the nose were 56.92 and 55.26 mm, respectively. The means of the nasal bridge width and morphologic nose width were 29.74 and 33.63 mm, respectively. The mean width of the anatomic nose was 23.14 mm. The mean width of the nostril floor was 11.00 mm. The means length and width of the ala were 19.93 and 4.81 mm, respectively. The means of length and width of the columella were 9.34 and 5.34 mm, respectively. The mean frontonasal angle was 134.96 degrees and the mean nasolabial angle was 90.32 degrees.

In 2006 Scavone et al.[54] conducted a study on facial profile evaluation in Japanese-Brazilian adults with normal occlusions and well-balanced faces. They found statistically significant differences in the Japanese-Brazilian sample compared with the white norms. Japanese-Brazilian women had more anteriorly positioned glabellae, smaller nasal projections, and more opened nasolabial angles than white American women. Japanese-Brazilian men had more anteriorly positioned glabellae, smaller noses, larger protrusions of the upper and lower lips, less projected B'-points, and more obtuse nasolabial angles than white American men.

In 2006 Leong and White[89] conducted a study to establish parameters of the average nose in the healthy population and to compare them with those of the aesthetic ideals. Aesthetic nasal proportions of 50 healthy Caucasians were examined from a cohort of 57 volunteers. Results showed that the average nose did not conform to neo-classical facial canons. The alar width (average 3.6 cm) was significantly wider than the intercanthal width (average 3.0 cm, $p<0.05$). The nasal width-length ratio was also greater suggesting that the cohort average was shorter and wider than the aesthetic ideal. The Baum ratio was 2.5:1, indicating that the average nasal tip was more projected that the aesthetic ideal (2.8:1). The naso-frontal and naso-facial angles are both more obtuse, and in profile the average nose overall appeared more prominent, as a result of the reduced forehead projection. The only parameter where there appeared to be consistency between the average and the ideal nose was the naso-labial angle.

In 2007, Krisztian Nagy et al.[55] established a computer analysis for nasal form and symmetry in primary and secondary cleft rhinoplasty outcomes. For assessing intranasal symmetry, the ratio of nasal tip projection to total nasal width, the ratio of nostril widths, the ratio of nostril heights, the ratio of mid-alar widths and nostril symmetry were determined. Bifidity of the nose, columellar deviation and angulations of the nostrils were also measured. For assessing the symmetrical position of the nose, the ratio of the distances of alar points to the endocanthial lines and nasal base inclination were determined. They found that this method is appropriate for comparing results of different surgical techniques

In 2007 Hoffelder et al.[56] studied soft-tissue changes during facial growth in skeletal Class II individuals. They investigated the changes in the thickness and the length of the soft tissues of the nose, upper and lower lips, and chin due to growth from 6 to 16 years of age. The study concluded that all structures showed some growth at all stages. The nose showed the greatest increases in thickness and length in both sexes. There was sexual dimorphism at 16 years, with higher values for boys. Upper lips tended to reduce in the girls. Upper lip length showed slight increases, and base of the upper lip showed small increases for both sexes.

In 2007 Mitchell et al.[87] through his article on nasolabial aesthetics, discussed about the nasolabial region and steps involved in performing a comprehensive aesthetic evaluation. He also discussed how the LeFort I osteotomy produces changes related to the external nasal morphology. He concluded that there is widening of the base of the nose and associated flattening and thinning of the upper lip, which is especially notice able in loss of the visible vermilion border. Other changes in the nasal tip and dorsum may or may not accompany the surgery, depending on the direction and magnitude of skeletal movement and the handling of the soft tissues, the skin thickness, and the pre-existing nasal structure. Soft tissue management after maxillofacial osteotomies is essential to producing a final pleasing aesthetic result.

In 2009 McCollum et al.[57] studied the sagittal soft-tissue changes related to the surgical correction of maxillary-deficient Class III malocclusions. They concluded that changes in the positions of hard- and soft-tissue landmarks for the nose, upper lip, lower lip, and chin area showed significant correlations for both horizontal and vertical movements of maxilla. Anterior nasal tip moves horizontally in a 0.26:1 ratio with upper incisor anterius and 0.34:1 with anterior nasal spine.

In 2009 Nehra & Sharma[23] conducted a study to investigate the relationship between nasal morphology and vertical maxillary skeletal pattern. There was a significant correlation between vertical maxillary skeletal and soft tissue nasal parameters. They concluded that Nasal length was significantly correlated to upper anterior facial height and inclination of palatal plane. An upturned nose in an adult individual was significantly correlated with anti-clockwise rotation of maxilla.

In 2009 Garandawa et al.[58] conducted a study to provide a set of standard values to the form of nose and its relationship with other facial structures of adult Nigerians. The mean length of the nose found in the study was 47.7 (4.9) mm, width of the nose was 42.2 (3.7) mm. The most common nostril type was Nostril type VI (41.3%). There was no significant difference in the distribution of nostril type between the sexes

In 2011 Esenlik et al.[59] conducted a study to identify and quantify nasal profile changes following maxillary advancement (MA) and maxillary advancement with impaction (MAI) with Le Fort I osteotomies. Results showed that nasal length, hump, nasal depths, distance from the most convex point of the alar curvature to the most inferior point of the nostril, alar curvature-subnasale, and subnasale-pronasale measurements decreased postoperatively. In the MAI group, MA correlated with significant decreases in nasal length and hump. In the MA group, MA correlated with pronasale position; significant decreases in nasal depth, columella convexity, and subnasale-pronasale length; and significant changes in subnasale position. They concluded that there was little difference in the effects of the 2 different maxillary surgeries on the postoperative nasal profile.

In 2011 Rauso et al.[60] conducted a study on nasolabial changes after maxillary advancement. The outcomes of this study show a general trend in the widening of the alar base with an associated shortening of the columellar length and lengthening of the base of the nose.

In 2011 Szychta et al.[61] conducted a study to compare the aesthetic results of post traumatic rhinoplasty among Europeans with populations of healthy Caucasians and to collate correct parameters of nasal shape in healthy representatives of both sexes and various races for improvement in aesthetic results of surgery. They concluded that in females, mean height and width of the nose as well as length of both nostrils was smaller. Nasal proportions were similar in both sexes. Some of the nasal angles differed in addition to gender. Posttraumatic rhinoplasty resulted in correct shape of the nose similar to the healthy Caucasian population.

In 2011 Howley et al.[83] conducted a study to evaluate the effect of an alar base cinch suture on the change in width of the alar base after Le Fort I osteotomy. Twenty-eight patients were prospectively randomised into an intervention group where a cinch suture was used, and a control group. The width of the alar base was measured before operation, and then at one, and six months. At six months it had increased from baseline by a median of 2 mm in all patients. The median increase was greater in the control group than in the cinch placement group, but the difference was small. The range in both groups was large, indicating great individual variability. There was an overall reduction in the width of the alar base between one and six months after operation, which indicated some resolution of soft tissue oedema associated with the operation, but the median reduction was small and unlikely to be clinically significant. The preliminary findings suggest that the suture confers little benefit in controlling the width of the alar base of the nose after Le Fort I osteotomy.

In 2012 Park et al.[82] conducted a study to evaluate nasal morphologic and maxillary skeletal changes occurring after bimaxillary surgery in skeletal class III patients. Sample consisted of 30 adult patients who underwent Le Fort I advancement and impaction osteotomy and mandibular setback surgery. The pre- and post-operative CBCT data were superimposed. The results showed that after surgery, the nasolabial angle, nasal tip angle, nasal tip inclination and columellar angle showed significant increases. The nasal tip protrusion and nasal height, meanwhile, had significantly decreased, and the alar base width had increased. The columellar length and nostril axis angle also had decreased, but the nostril area did not show any significant change. They concluded that after surgery, as the maxilla had been moved upward and forward, the nasal tip was shifted antero-superiorly and the alar base width and nostrils were widened.

In 2013 Bottini et al.[90] studied the changes in nasal profile following maxillomandibular osteotomy for prognathism. 25 patients (13 women, 12 men) who underwent orthodontic-surgical treatment for correction of maxillomandibular deformities were studied. Pre- and postoperative clinical, photographic, and cephalometric analysis were carried out to assess modifications of the nasal shape due to maxillary osteotomies. They concluded that it is inadvisable to perform rhinoplasty at the time of orthognathic surgery to correct preexisting defects, such as a dorsal hump, a nasal base that is too wide or too narrow, a nasal pyramid deviation, or other esthetic defects resulting from orthognathic surgery. Instead, it is recommended to postpone nasal corrective surgery by 8 to 12 months, by which time the bony structures and the soft tissues of the nasal region will be stabilized, all the edema subsided, the resulting and pre-existing defects of the external nose more defined, and consequently a more corrective surgery performed

In 2014 Prasad et al.[62] conducted a radiographic study to evaluate the relationship between nasal morphology and maxillary skeletal pattern. They concluded that long nose with increased nasal prominence were seen with increase in the anteroposterior length and vertical height of maxilla. Male and female genders had a varied amount of nasal length, nasal depth and columella convexity along with nasal tip angle.

In 2014 Jafarpour F et al.[63] compared cephalometric nose morphology among Filipino female and male adults with skeletal class I, II and III relationships. Upper and lower facial height, nose height, nose length, nose tip projection, were measured in cephalograms. They concluded that Filipino males have longer nose with less prominent tip in comparison with females. Angular measurements of nose are larger in class II malocclusion in comparison with class I and class III.

In 2014 Tanikawa and Takada.[64] conducted a study to objectively classify the nose-lip-chin profiles of adult women and identify any associations between the nose-lip-chin profile patterns and dentoskeletal patterns. Lateral facial photographs and lateral cephalograms of 229 Japanese women were assessed. Eight profile patterns were identified, and the differences among patterns were notably maximized by the nasolabial angle, configuration and vertical length of the subnasal region, vertical thickness of the lip vermilion borders, sagittal position of the upper- and lower-lip vermilion borders and their relation to each other, labiomental angle, depth of the labiomental sulcus, degree of prominence of the chin, and degree of protrusion of the mandible. They found significant differences between dentoskeletal patterns and the classified profile patterns.

In 2015 Peacock and Susarla[65] conducted a study on the role of pyriform ligament in alar width maintenance after Le Fort I Osteotomy. They concluded that the pyriform ligament is easily identified during exposure of the maxilla and pyriform aperture can be used to control widening of the alar base after Le Fort I osteotomy.

In 2015 S. Worasakwutiphong et al.[66] analysed nasal changes after orthognathic surgery for patients with prognathism and Class III malocclusion using three-dimensional photogrammetry. Results showed that after the surgery, characteristic nasal changes occurred with an increase of nasolabial angle and nostril show, but a preserved nasal width. In the self-perception, 37% of patients reported improved nasal appearance, 58% reported no change, and 5% were not satisfied with the nasal changes.

In 2015 Bhushan et al.[67] conducted a study to assess the relationship between maxillary inclination and nasal morphology in males. The results suggested that there was statistically significant difference in nasal height, nasal bone length (NBL), nasal depth, nasolabial angle (NLA), nasal tip angle and upper lip inclination angle in different maxillary inclination group. The nasal height, NBL, NLA and nasal tip angle had a maximum value in retro inclination group.

In 2015 Olate et al.[68] conducted a study to ascertain the nasal characteristics in patients with a Class III dentofacial deformity. They concluded that there are nasal deformities in subjects with a Class III facial deformity and this component must be carefully evaluated in the preoperative stage.

In 2015 Dantas et al.[85] conducted a study to evaluate the anatomic alterations of the nasal region in patients undergoing a Le Fort I osteotomy for advancement or superior impaction. Twenty-one patients were evaluated during the pre- and postoperative periods. The positioning of the nasal tip and the modification of the nasal base were evaluated. The results showed that the nasal tip was superiorly positioned in 85% of the cases, advanced in 80%, rotated in 80%, and there was a wide nasal base in 95%, resulting in esthetic improvement. They concluded that surgeries of maxillary advancement and superior reposition tend to cause elevation and advancement of the nasal tip, as well as enlargement of the nasal base.

In 2016 Thakur et al.[69] conducted a study to evaluate the relationship between craniofacial structures and nose in Himachal population. Results showed that nasal length and Nasal Depth showed positive correlation with the length of maxillary and mandibular jaws and facial height. Nasal hump, Nasolabial angle, Nasal base angle and Columella convexity showed no correlation with the underlying craniofacial structures. They concluded that nose is related to underlying craniofacial structures in Himachal adult population. Himachal males have a longer protrusive nose with nasal tipped downwards and females have a shorter and lesser protrusive nose with nasal tip turned upwards.

In 2017 Khare V et al.[70] evaluated the effect of vertical maxillary skeletal pattern on nasal morphology in high and low angle cases. The sample included the lateral cephalometric radiographs of 100 Indian adults aged 16 to 25 years, with the mean age of 20 years with vertical maxillary excess divided equally into a high and low angle. They concluded that vertical midface discrepancy may not be completely reflected in nasolabial angle itself; however, nasal length, nasal depth, and form may indicate an underlying change in inclination of the palatal plane and skeletal growth pattern.

In 2017 Krishnaveni S et al.[71] studied the lateral cephalogram of 60 adults of age 18-27 years to find the relationship between nasal morphology in relation to sagittal and vertical maxillary skeletal pattern and the relationship between the degree of upturn of the nose and the inclination of the palatal plane. 10 facial skeletal parameters and 6 nasal parameters were measured on lateral cephalograms. Vertical facial skeletal parameters assessed were mandibular plane inclination to the cranium, posterior facial height, anterior facial height, anterior maxillary height, Lower Anterior Facial Height, The angle between the Sella-Nasion plane and the ANS-PNS line and Angle of inclination. Soft tissue landmarks assessed were Soft tissue nasion, Pronasale (Pr), Posterior columella point (PCm), subnasale (Sn) and labrale superius (Ls). Reference planes and variables used to assess the nose was Nasal length (N Lth), Nasal depth (N Dpt), Nasolabial angle (NLA), Nasal upward tip angle (UNLA), Upper lip inclination (LNLA) and Nasal tip angle (NTP). They concluded that nasal length, prominence, and form are associated with height and length of the maxilla. Nasolabial angle in itself may not indicate a mid-face vertical discrepancy; however, its upper component, with decreased nasal length in an adult subject may indicate an underlying change in inclination of the palatal plane.

In 2017 Umale et al.[72] conducted a cephalometric study to evaluate sexual dimorphism in nasal proportions of Class I and Class II skeletal malocclusions in adults. They concluded that sexual dimorphism was found in various nasal parameters. Significant number of differences was found in the nasal proportions of Class I and Class II (male and female) participants

In 2017 Shin et al.[74] studied the nasal deviation in patients with asymmetric mandibular prognathism. They concluded that mandibular chin deviation was accompanied by nasal deviation. Isolated mandibular surgery can potentially influence the alar base position on the contralateral side of deviation but not the nasal tip asymmetry.

In 2017 Strapasson et al.[73] conducted a study to evaluate the relationships between alar cartilage and piriform aperture and nose morphology and facial typology. They found that nasal width is associated with the lower width of the piriform aperture, sex, skeletal vertical pattern of the face, and age. The long face type was found to be associated with nasal width. The male nose was 3.72 mm (mean) wider than the female nose.

In 2017 Mehta and Srivastava[94] conducted an anthropometric analysis on Indian nose. They conducted a descriptive cross-sectional epidemiological study of 1000 volunteers, with equal number of subjects derived from five geographic groups, namely North, Central, West, South, and the Himalayan region, to determine differences in nasal morphology of Indian population and among its various regions. The objective was to establish a standard Indian data for guidance in nasal surgery. All measurements were deduced using photographic analysis. The mean nasal height and width of the population was 50.48 and 36.59 mm, respectively. Nasal profile varied among all five regions of the country. North Indians had the longest (52.69 mm nasal height) but the narrowest nose (35.01 mm width), thus having a leptorrhine nose with Caucasoid features. South Indians had the broadest nose (nasal width = 38.66 mm), whereas subjects from the Himalayan region had the shortest nose (nasal height = 47.2 mm). Indians on average had a mesorrhine nose as compared to Caucasians and Orientals who have a leptorrhine nose and Africans who have a platyrrhine nose. They concluded that the Indian nose should be considered a different entity in comparison to the nose of Caucasi an, Oriental, and African populations.

In 2018 Bhardwaj et al.[75] evaluated certain nasal parameters in Angle Class I, II, and III malocclusion and its association with different growth patterns and gender. The nasal parameters used were nasal length (N Lth), nasal depth, nasolabial angle (NLA), and lower nose to Frankfort horizontal (LNFH) plane angle. They found that among the different malocclusion groups of Class I, II, and III, N Lth was found to be greater in Class III adults. NLA and LNFH angle was higher in adults with vertical growth pattern. However, there was no gender dimorphism found for nasal parameters

2019 Radha and Srinivasan[93] conducted a study to measure the values of the nasal height, nasal breadth and nasal Index in South Indian population. Nasal height and breadth were measured using Digital Vernier Caliper. Nasal index was calculated and the results were statistically analysed. Results showed that the mean height and breadth of nose in males were 55.75 mm and 37.26 mm and for females were 53.89 mm and 34.59 mm. Nasal index was found to be 67.0 for males and for 64.8 females. And moreover the most common nasal type was found to be Leptorrhine followed by Mesorrhine type.

In 2020 Sazgar et al.[76] carried out a study on the deidentified photographs of 122 patients to classify nostril shape. Classification was performed using two views: frontal and basal. In the frontal view, nostrils were divided into two types according to the visibility of the sill's ridge and the shadow of the nostril's opening. In the basal view, nostrils were categorized into three types based on the shapes of the nostrils.

In 2021 Sahoo et al.[77] published a systematic review on relationship of nasal morphology with different dentoskeletal patterns. A total of 15 articles were selected for study. They concluded that the nose is found to be convex in skeletal class II, straight in class I, and concave in class III. Those with increased vertical growth may have an increased tendency of a convex nasal dorsum. Maxillary and mandibular jaw length affect the nasal parameters more than the jaw position. Nasal length and nasal depth increase with the jaw length and mandibular and maxillary/palatal-plane inclination to the cranium. A long nose with increased nasal depth is expected in long faces and those with long upper and lower jaws. An upturned nose is found with an anticlockwise-rotated maxilla.

In 2021 Weiliang et al.[97] describe the average values of the nasal anthropometric measurements in Han Nationality young female population in Central China. The means of the linear measurements of the external nose in this study were as follows: nasal height (48.9 mm), nasal bridge length (43.3 mm), morphological facial height (110.4 mm), facial width (125.1 mm), intercanthal width (35.9 mm), nasal tip protrusion (21.1 mm), nasal width (35.5 mm), nasal ala length (27.9 mm), nasal ala thickness (4.1 mm), columella height (8.9 mm), columella width (6.0 mm). The means of the angular measurements of the nose were as follows: nasofrontal angle (143.3 degree), nasofacial angle (34.1 degree), nasal tip angle (80.4 degree), nasolabial angle (97.3 degree).

In 2022 Fan et al.[78] conducted a study to objectively quantify nasal characteristics of patients with asymmetric mandibular prognathism and to evaluate the association between nasal asymmetry and dentofacial abnormalities. Nasal characteristics and asymmetry were quantified by anthropometric linear distances, angular measurements, and surface-based analysis. The results showed that the nasal tip was significantly shifted to the deviated side of the chin, and the nostrils were asymmetrical. The location and degree of nasal asymmetry varied among patients with asymmetric mandibular prognathism. The level of nasal asymmetry was significantly and positively correlated with chin and periorbital asymmetry

In 2023 Saurabh Sharma et al.[92] conducted a study to evaluate the Nasal Index and its Role in Sexual Dimorphism in Central Indian Population.

Posteroanterior (PA) and Cephalogram (Ceph) was taken for all the study subjects both clinically and radiographically. Nasal Height (NH) and Nasal Breadth (NB) was measured. NI was then calculated as NB/NH×100. Results showed that the radiographic findings of NH were found to be statistically higher in males (47.46±2.26 mm) while clinical findings of NH were found to be statistically higher in females (55.66±3.21 mm). Radiographic findings and clinical findings of NB were found to be statistically higher in males (33.95±2.41 mm, 37.19±2.44 mm) as compared to females (30.55±1.50 mm, 32.41±1.58 mm). Radiographic findings and clinical findings of the NI were found to be statistically higher in males (71.70±6.21,69.94±5.87) as compared to females (67.02±5.21, 58.44±4.70). They concluded that nasal parameters showed significant differences between males and females in Central Indian population, suggesting sexual dimorphism.

Relevance Of the study

RELEVANCE OF THE STUDY

The face is the most exposed part of the human body. When the aesthetics are compromised, a patient may develop a negative body image and psychological disturbances. It is well known that severe deformity of the face and severe malocclusion can lead to introverted personality and psychological stress. Skeletal malocclusion is the abnormal position of the jaws relative to each other and to the face. Orthognathic surgery is the ideal treatment for skeletal malocclusion for non-growing individuals.

Diagnosis of malocclusion is important for a proper treatment plan. The lateral cephalogram is a diagnostic tool for identifying skeletal as well as dental malocclusion. Clinical evaluation of malocclusion is also important for proper diagnosis. Studies shows that nasal length, height, shape and prominence are associated with maxillary length and height.[5] Since the nostril is a part of the nose and easy to evaluate, finding the relation between the maxilla and the nostril will help in diagnosis and treatment planning.

Some studies reported widening of the alar base and shortening of the columellar length with maxillary advancement surgery. Awareness about nostril shape in each skeletal pattern is important in rhinoplasty surgery. It helps the physician to do rhinoplasty according to the patient’s profile. It also helps the surgeon to decide whether rhinoplasty is required along with maxillary osteotomy.

Materials & Methods

STUDY DESIGN

This study was designed as a Cross-sectional study with 186 subjects - 62 Class I skeletal patients, 62 Class II skeletal with maxillary prognathic patients and 62 Class III skeletal with maxillary retrognathic patients.

STUDY SETTING

This study was conducted on patients reporting to Department of Orthodontics & Dentofacial Orthopedics, St. Gregorios Dental College, Chelad, Kothamangalam.

SAMPLING

Data was analyzed using the statistical package SPSS 22.0 (SPSS Inc., Chicago, IL) and level of significance was set at $p<0.05$. Descriptive statistics was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using Shapiro Wilkinson test. Inferential statistics to find out the difference between and within the groups were done using ONEWAY ANOVA and TUKEY'S POST HOC. CHI SQUARE TEST or FISHER'S EXACT TEST was used to check the difference in proportion between the groups. The total sample size was estimated at 61.44 with a power of 80%. The sample size was rounded off to 62 for each group and total of 186.Sample size.

$$\text{Necessary sample size} = \frac{(\text{Z score})^2 \times \text{StdDev} \times (1\text{-StdDev})}{(\text{margin of errors})2}$$

n = (Z α 2(d)2×SD(1-SD)

Z α = Type 1 error (5%) = 1.96

SD = Standard deviation = 0.8 (From literature)

d= margin of error= 0.1(10%)

$$n = \frac{(1.96)^2 \times 0.8 \times 0.2}{0.12}$$

$$n = \frac{3.84 \times 0.16}{0.01} = 61.44 \approx 62 \text{ samples}$$

FINAL SAMPLE SIZE = 62 ×3=186

The total sample size was estimated at 61.44 with a power of 80%. The sample size was rounded off to 62 for each group and total of 186.

INCLUSION CRITERIA

- Age:- 15-25 years
- Normal body mass index (18.5-24.5)

Cephalometric values		Class I	Class II	Class III
	SNA	82^{0}	$>82^{0}$	$<82^{0}$
	ANB	2^{0}	$>2^{0}$	$<2^{0}$
	N perpendicular to point A	0±2 mm	>2 mm	<-2 mm

EXCLUSION CRITERIA

- Patient with previous history of orthodontic treatment or orthognathic surgery
- A significant medical or dental history
- Craniofacial abnormality including cleft lip
- Patient with abnormal tongue size
- Patients with habits like tongue thrusting, mouth breathing
- Patients with history of trauma induced fracture of jaw bones
- Periapical or peri radicular pathologies or radiolucencies of either periodontal or endodontic origin.

MATERIALS

- DSLR camera (Nikon D3500, Sensor – 23.5×15.6 mm CMOS, Effective pixel density – 24.2-million-pixel, Lens – AFP Nikon 18-55 mm lens)
- Image J software
- Lateral cephalogram
- HP laptop supporting windows 11 with Intel core i3 processor

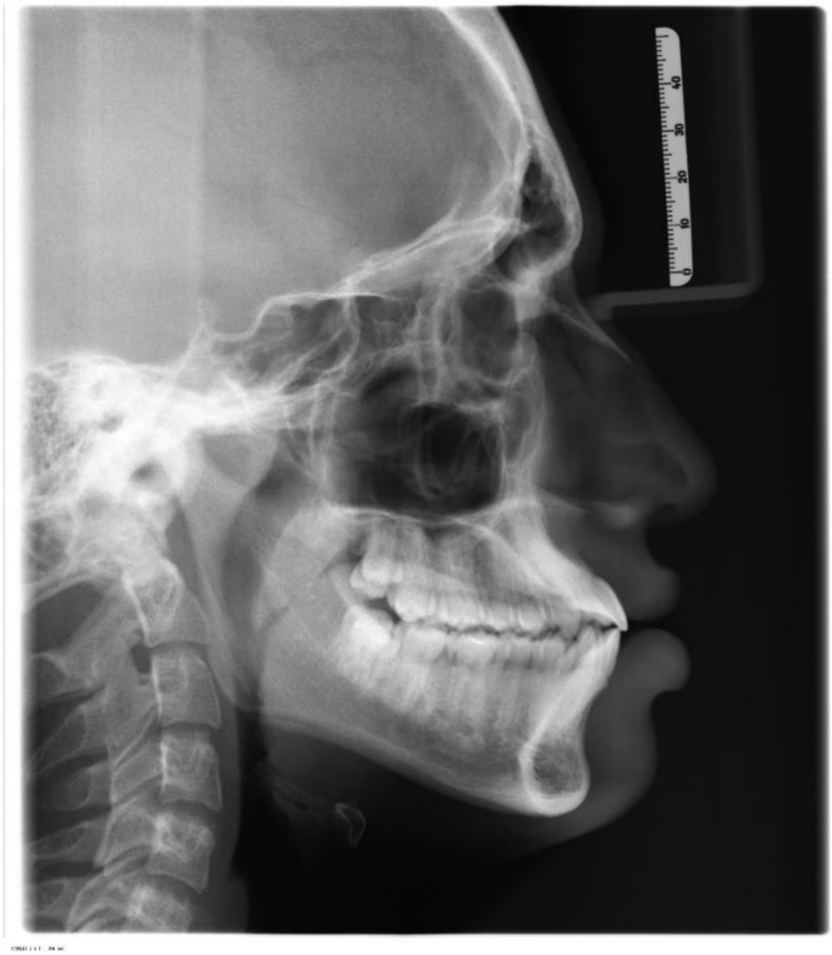


Figure 2: LATERAL CEPHALOGRAM

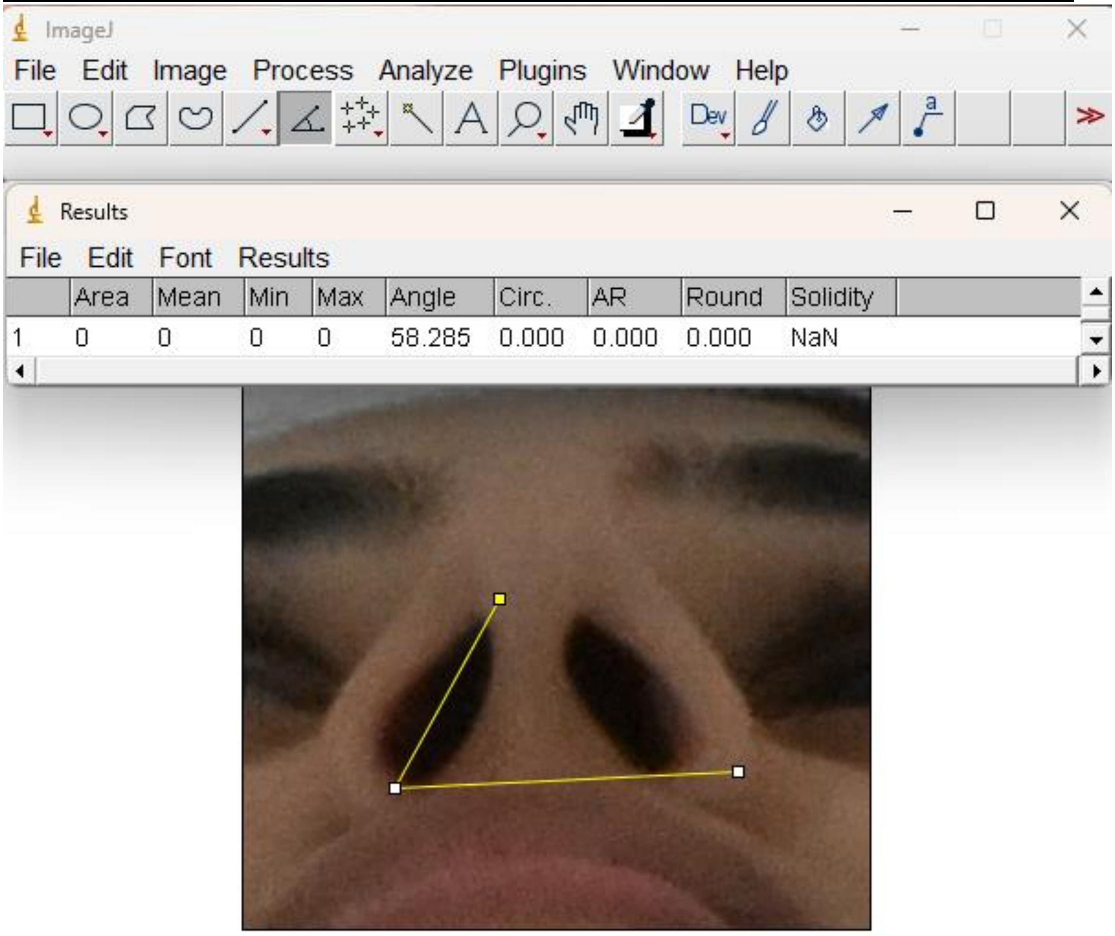


Figure 3: IMAGE J SOFTWARE

Figure 4: DSLR CAMERA

METHODOLOGY

The current study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, St. Gregorios Dental College, Chelad, Kerala. 186 patients with Skeletal class I, Skeletal class II with maxillary prognathism and Skeletal class III with maxillary retrognathism, between age group of 15-25 years were selected for the study. The selection of the patients was based on the above-mentioned inclusion and exclusion criteria described for the study. Informed consent was obtained from all participants. The study protocol was approved by the Institutional Ethical Committee (SGDC/152/2022/4343).

Photographs of the participants were taken using Nikon DSLR camera in profile and submento vertex view. Patient was asked to stand on a line marked on the floor which was 100cm from the camera and asked him to relax the face. Photographs were taken by a single operator. Photographs taken in JPEG format were digitalized and analyzed using Image J software.

For the profile view, the patient was asked to look straight ahead and the head was aligned to the Frankfort Horizontal Plane. For basal view, the patient's head was tilted back until the nasal tip was aligned with the glabella. To correct the differences in image magnification or facial angles in the basal view, the ratios of the left and right sill heights were measured. If the ratio value is 1, it indicates no asymmetry in sill heights.[76]

Assessment of the angulation of the nostril were done from base of the nostril to the apex of the nostril. The inclination of the medial longitudinal axis of the nostrils was measured and classified using modified Topinard classification given by Farkas et al.[30] Measurement of angle was done using Image J Software.

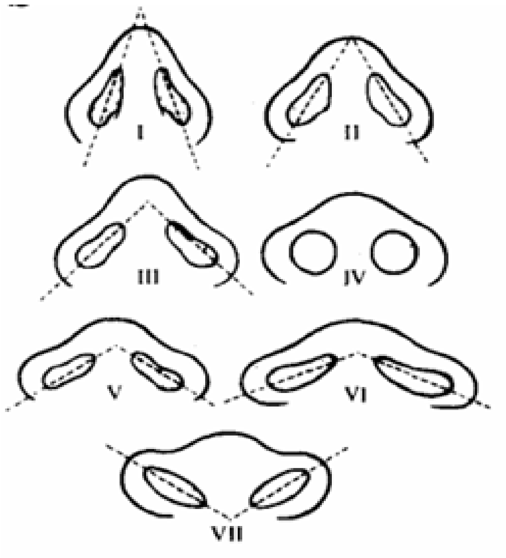


Figure 5: NOSTRIL CLASSIFICATION

Classification	Inclination
Type I	70-90⁰
Type II	55-69⁰
Type III	40-54⁰
Type IV	0⁰
Type V	25-39⁰
Type VI	10-24⁰
Type VII	-50 to -20⁰

Table 1: NOSTRIL CLASSIFICATION

Photographic setup

Photographic setup consists of a DSLR camera with 35 mm focal length. Camera should be at the level of nose tip of the patient. The patient was asked to stand on a line marked on the floor which was 100cm from the camera and asked him to relax the face. Photographs taken in JPEG format were digitalized and analyzed using Image J software.

Figure 6: PHOTOGRAPHIC SETUP

Measurement of nostril

Inclination of the median longitudinal axis of the nostril was measured.[30] A line connecting the top and bottom points of the medial longitudinal axis of the nostril was drawn. Another line was drawn by connecting the base of the both nostrils. Angle between these two lines indicates inclination of nostrils. This angulation was measured using Image J software. Nostril was classified using modified Topinard classification.

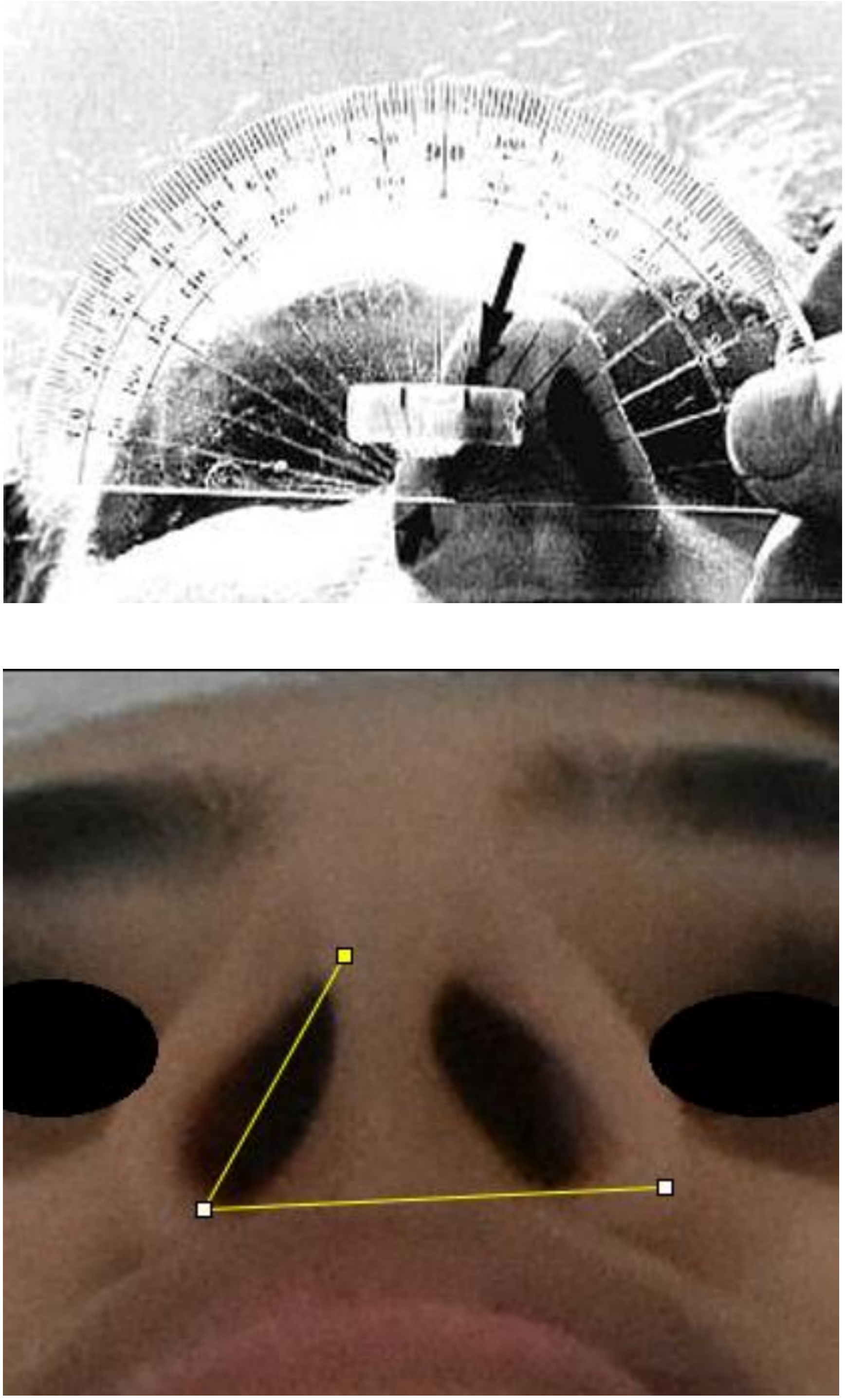


Figure 7: MEASUREMENT OF NOSTRIL

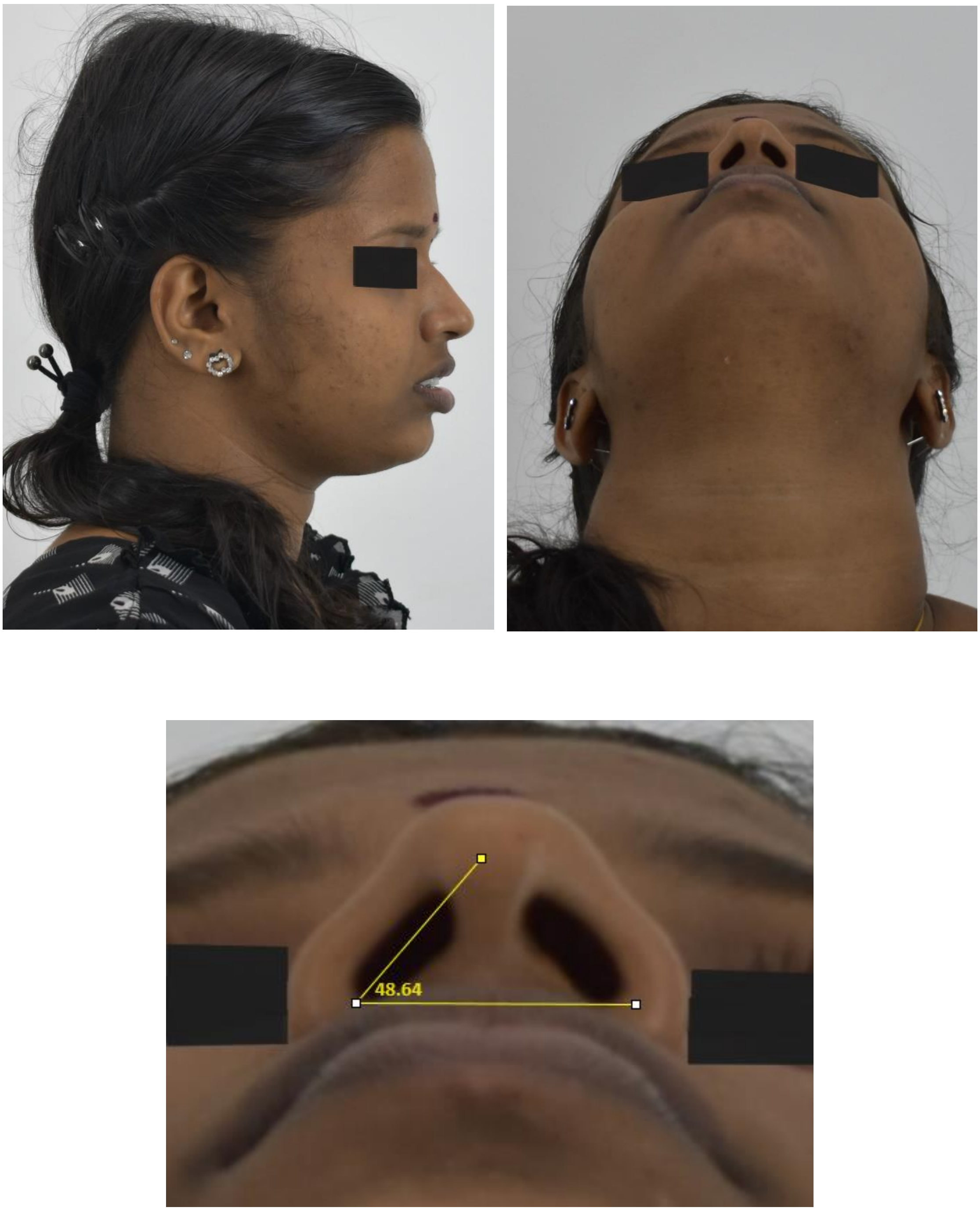


Figure 8: SKELETAL CLASS I MALOCCLUSION

Figure 9: SKELETAL CLASS II MALOCCLUSION

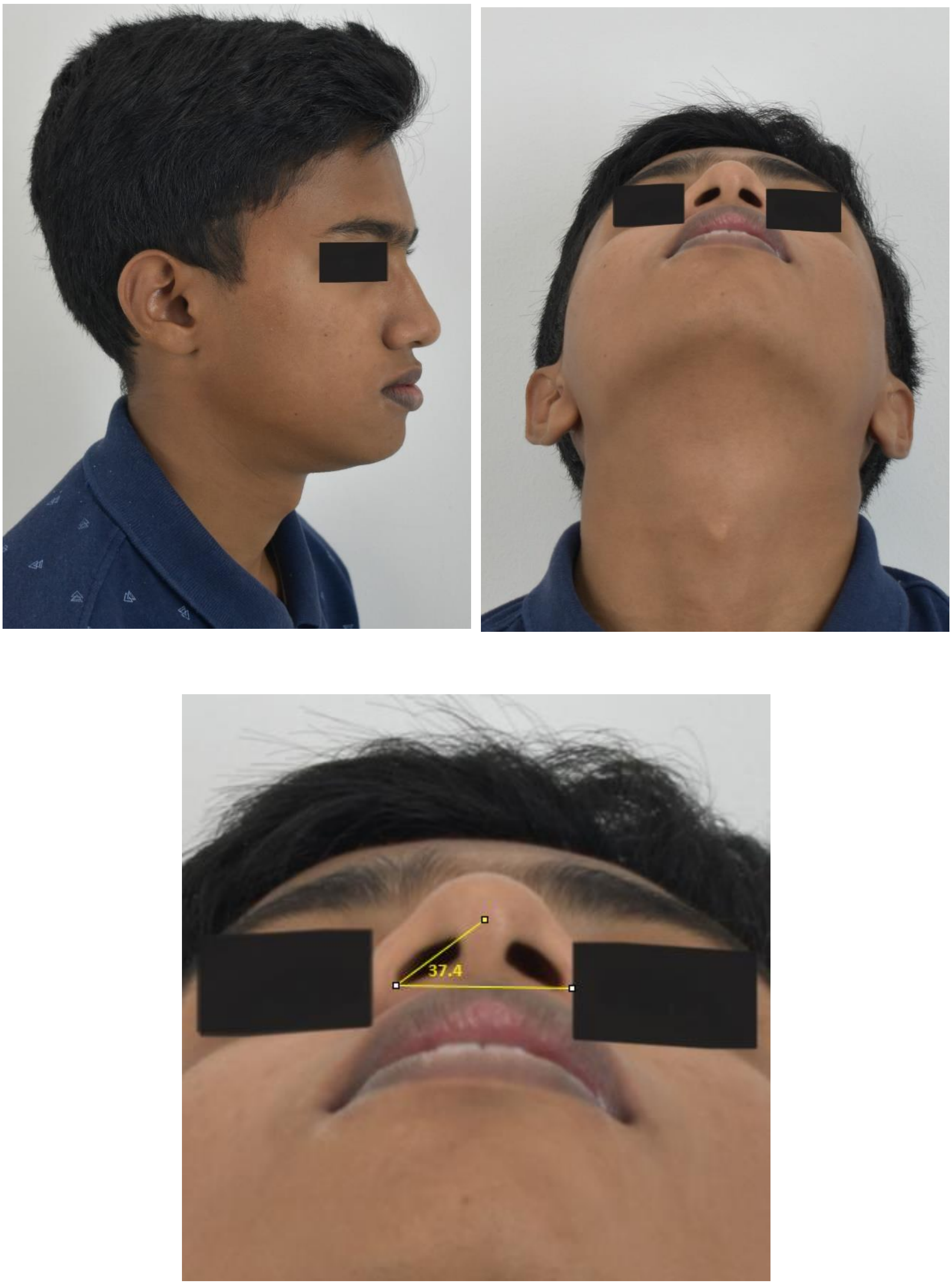


Figure 10: SKELETAL CLASS III MALOCCLUSION

Results

STATISTICAL ANALYSIS

Data was analyzed using the statistical package **SPSS 26.0** (SPSS Inc., Chicago, IL) and level of significance was set at **$p<0.05$**. **Descriptive statistics** was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using **Shapiro Wilkinson test**. **Inferential statistics** to find out the difference within the group was done using **ONE WAY ANOVA** followed by **BONFERRONI POSTHOC TEST. INDEPENDENT T TEST** was used for analysing the difference between 2 groups. **CHI SQUARE TEST** was used for analysing association.

RESULTS

DEGREE OF INCLINATION OF NOSTRIL

Mean degree of inclination of nostril in each skeletal pattern is given below. Mean degree of inclination in Class I skeletal pattern was 46.98±5.57⁰. In Class II skeletal pattern with prognathic maxilla mean degree of inclination was 55.32±4.9⁰. In Class III patients with retrognathic maxilla, mean degree of inclination was 37.63±4.37⁰.

		CLASS I	CLASS II	CLASS III
Mean		46.9863	55.3231	37.6327
95% Confidence Interval for Mean	Lower Bound	45.5696	54.0535	36.5290
	Upper Bound	48.4030	56.5926	38.7364
5% Trimmed Mean		46.9885	55.1432	37.7446
Median		47.4000	55.8000	37.8000
Variance		31.120	24.992	18.889
Std. Deviation		5.57857	4.99925	4.34610
Minimum		35.80	44.70	25.30
Maximum		57.80	70.27	46.80
Range		22.00	25.57	21.50
Interquartile Range		9.73	6.29	3.47
Skewness		-.071	.301	-.359
Kurtosis		-.861	.769	.971

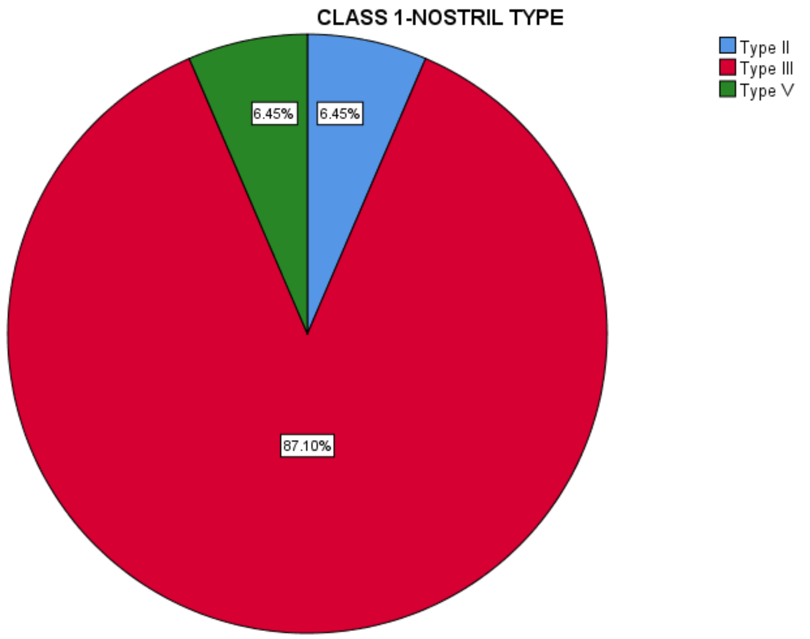
Table 2- Descriptive details of Degree of Inclination

NOSTRIL TYPE IN CLASS I

The nostril type in Class I skeletal pattern is depicted in Table 3 and Graph 1. The results show that the most common type of nostril in Class I skeletal pattern was Type III, which was 87.1% of total Class I sample. Type II and Type V nostrils also seen in Class I skeletal pattern, 6.5% each.

		Frequency	Percent
CLASS I	Type II	4	6.5
	Type III	54	87.1
	Type V	4	6.5
	Total	62	100.0

Table 3 – Nostril Type in Class I



Graph 1

Type III nostril was found in 54 samples with mean value of 49.99±4.51⁰. Type II nostril was found in 4 samples with mean value of 56.95±1.18⁰. Type V nostril was found in 4 samples with mean value of 36.84± 1.11⁰. Mean value of degree of inclination in Class I skeletal pattern was 46.98±5.57⁰.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
TYPE II	4	56.900	1.18462	.59231	55.0650	58.8350	55.20	57.80
TYPE III	54	46.9998	4.51722	.61472	45.7669	48.2328	40.00	54.00
TYPE V	4	36.8400	1.11940	.55970	35.0588	38.6212	35.80	38.10
Total	62	46.9863	5.57857	.70848	45.5696	48.4030	35.80	57.80

Table 4: Descriptive details of Degree of Inclination in CLASS I based on Nostril Type

Significance of the results is depicted in table 5. Shapiro Wilkinson test for normality did not report significant difference (p>0.05), hence Parametric tests are used for the analysis. Within Class I group, regarding Degree of Inclination, between nostril groups analysis was done by ONE WAY ANOVA and reported significant difference with P value of 0.000.

ANOVA					
CLASS I					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	808.901	2	404.450	21.903	.000
Within Groups	1089.446	59	18.465		
Total	1898.347	61			

Table 5 -Comparison of Degree of Inclination in Class I group Using One Way ANOVA

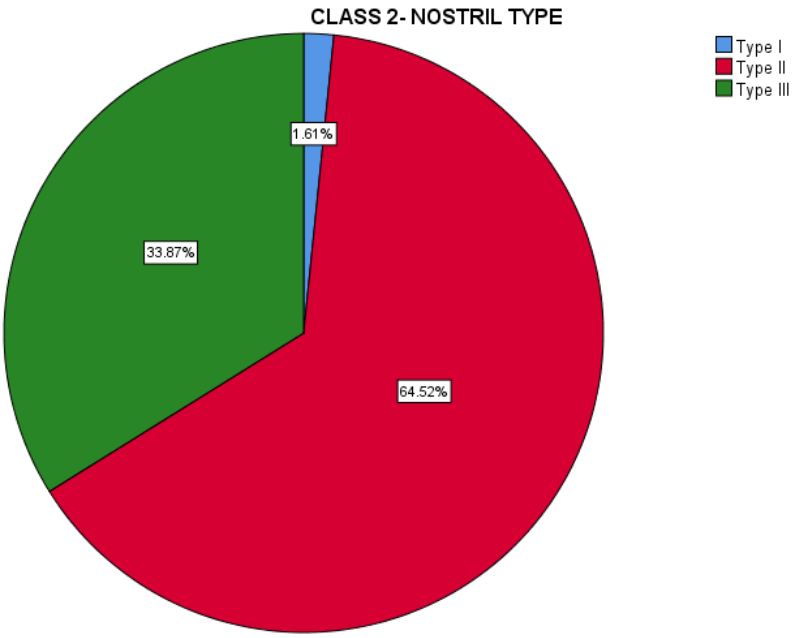
*P<0.05 is statistically significant (Shapiro Wilkinson test, P>0.05)

NOSTRIL TYPE IN CLASS II

The nostril type in Class II prognathic maxilla is explained in Table 6 and Graph 2. Type II was the most common type nostril in Class II maxillary prognathic patients. Type II was 64.5% of total Class II samples. Type I nostril seen in 1.6% of total Class II skeletal pattern. Type III seen in 33.9% of Class II samples.

		Frequency	Percent
CLASS II	Type I	1	1.6
	Type II	40	64.5
	Type III	21	33.9
	Total	62	100.0

Table 6: Nostril type in Class II



Graph 2

Type II nostril was found in 40 samples with mean value of 57.8±2.8⁰. Type I nostril was found in 1 sample with value of 70. Type III nostril was found in

21 samples with mean value of 49.89± 2.55⁰. Mean value of degree of inclination in Class II skeletal pattern due prognathic maxilla was 55.32±4.99⁰.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
TYPE I	1	70.2700	.	.	.	.	70.27	70.27
TYPE II	40	57.8010	2.80179	.44300	56.9049	58.6971	54.80	66.70
TYPE III	21	49.8914	2.54771	.55595	48.7317	51.0511	44.70	54.10
Total	62	55.3231	4.99925	.63491	54.0535	56.5926	44.70	70.27

Table 7- Descriptive details of Degree of Inclination in CLASS II based on Nostril Type

Significance of the result is depicted in table 8. Shapiro Wilkinson test for normality did not report significant difference (p>0.05), hence Parametric tests are used for the analysis. Within Class II group, regarding Degree of Inclination, between nostril groups analysis was done by ONE WAY ANOVA and reported significant difference with P value of 0.000.

ANOVA					
CLASS II					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1088.574	2	544.287	73.659	.000
Within Groups	435.968	59	7.389		
Total	1524.541	61			

Table 8 -Comparison Of Degree of Inclination in Class II group Using One Way ANOVA

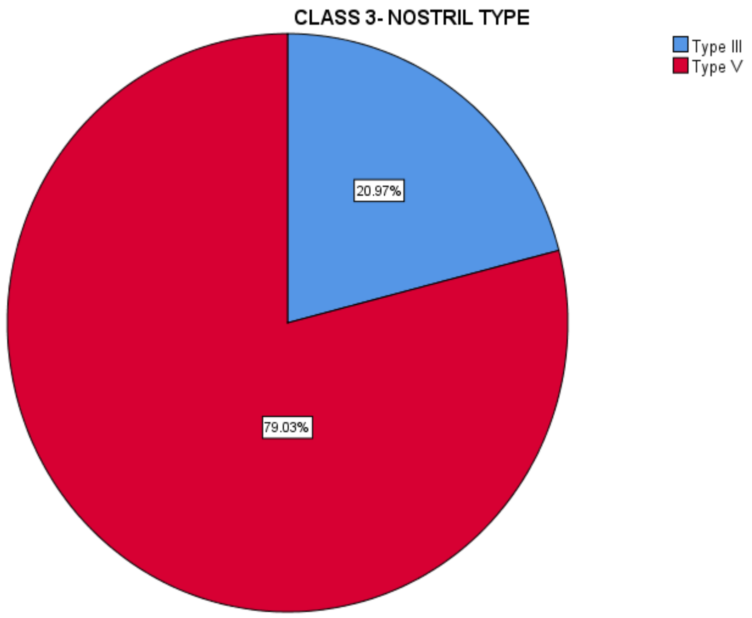
*P<0.05 is statistically significant (Shapiro Wilkinson test, p>0.05)

NOSTRIL TYPE IN CLASS III

The nostril type in Class III skeletal due to maxillary retrognathism is depicted in Table 9 and Graph 3. Most common type nostril in Class III retrognathic maxilla was Type V, which was 79% of total Class III skeletal sample. Type III nostril was seen in 21% of Class III sample.

		Frequency	Percent
CLASS III	Type III	13	21.0
	Type V	49	79.0
	Total	62	100.0

Table 9: Nostril type in Class III



Graph 3

Type V nostril was found in 49 samples with mean value of 36.08±3.32⁰. Type III nostril was found in 13 samples with mean value of 43.48± 2.24⁰. Mean value of degree of inclination in Class III skeletal pattern due retrognathic maxilla was 37.63±4.37⁰.

Group Statistics					
	NOSTRIL TYPE	N	Mean	Std. Deviation	Std. Error Mean
CLASS III	TYPE III	13	43.4869	2.23779	.62065
	TYPE V	49	36.0796	3.31782	.47397
	TOTAL	62	37.6237	4.34610	

Table 10- Descriptive details of Degree of Inclination in CLASS III based on Nostril Type

Significance of the result is depicted in Table 11. Shapiro Wilkinson test for normality did not report significant difference (p>0.05), hence Parametric tests are used for the analysis. Within Class III group, regarding Degree of Inclination, between nostril groups analysis was done by INDEPENDENT t test and reported significant difference with P value of 0.000.

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Differene	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
CLASS III	7.581	60	.000	7.40733	.97704	5.45296	9.36171

Table 11 -Comparison of Degree of Inclination in Class III group Using Independent t test

*P<0.05 is statistically significant (Shapiro Wilkinson test, p>0.05)

<u>ASSOCIATION BETWEEN MALOCCLUSION GROUPS & NOSTRIL TYPES</u>

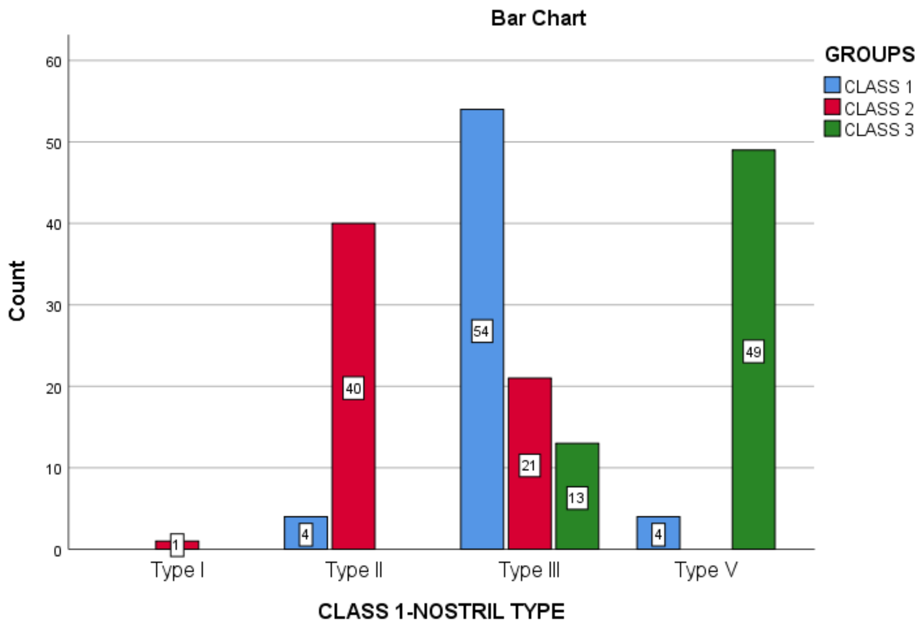
Table 12 depicts the association between Class I skeletal, Class II prognathic maxilla and Class III retrognathic maxilla with different nostril types. Chi

Square association table reported a statistically significant association present between different malocclusion groups and nostril types with P value of 0.0001.

		MALOCCLUSION			Total	P VALUE
		CLASS I	CLASS II	CLASS III		
NOSTRIL TYPE	Type I	0	1	0	1	0.0001*
	Type II	4	40	0	44	
	Type III	54	21	13	88	
	Type V	4	0	49	53	
Total		62	62	62	186	

Table 12: Chi Square Association table between Malocclusion groups & Nostril types

*P <0.05 statistically significant



Graph 4

The present study evaluated the inclination of nostril in skeletal Class I patients, Class II patients with maxillary prognathism, and Class III patients with maxillary retrognathism. Data was collected from the patients who reported in the Department of Orthodontics and Dentofacial Orthopedics, St.Gregorios Dental College, Kothamangalam. 62 patients with skeletal class I, 62 patients with skeletal class II with maxillary prognathism and 62 patients with skeletal class III with maxillary retrognathism, between age group of 15-25 years were selected for the study. Profile and basal view photographs of patients were used for the study. These photographs were digitalized and measurements were taken using Image J software.

The angulation of the nostril was assessed. Angle between the base of the nostril and long axis of the nostril was measured using Image J software. Each nostril was classified using modified Topinard classification.

Results of the study are given below:

- Mean degree of inclination in Class I skeletal pattern was 46.98 ± 5.57^{0}.

- In Class II skeletal pattern with prognathic maxilla mean degree of inclination was 55.32 ± 4.9^{0}.

- In Class III patients with retrognathic maxilla, mean degree of inclination was 37.63 ± 4.37^{0}.

- Most common type of nostril in Class I skeletal pattern was Type III (87.1% of total Class I sample). Type II (6.5%) and Type V (6.5%) nostrils also seen in Class I skeletal pattern. Regarding Degree of Inclination statistically significant difference (P value – 0.000) was found within Class I group.

- Type II (64.5% of total Class II sample) was the most common type nostril in Class II maxillary prognathic patients. Other types of nostrils seen in Class II skeletal pattern were Type I (1.6%) and Type III (33.9%). Regarding

Degree of Inclination statistically significant difference (P value – 0.000) was found within Class II group.

- Most common type nostril in Class III retrognathic maxilla was Type V (79% of total Class III skeletal sample). Type III (21%) nostril was also seen in Class III sample. Regarding Degree of Inclination statistically significant difference (P value – 0.000) was found within Class II group.

- Statistically significant association present between different skeletal malocclusion groups and nostril types with P value of 0.0001.

Discussion

The improvement of facial aesthetics is one of the desirable objectives of orthodontic treatment.[70] Orthodontists are interested in facial aesthetics for many years.[70] The soft tissue covering of the face plays an important role in facial aesthetics, speech, and other physiologic functions.[70] Thus, success of orthodontic treatment is closely related to the changes in soft tissues of the face.[70] The nose dominates the middle portion of the face and it influences the facial aesthetics. Thorough knowledge of the relationship between these facial structures, and the changes expected during the growth and with orthodontic and surgical treatment is essential for an orthodontist to achieve the desired treatment goals.[70]

Subtelny[2] studied the soft tissue facial structures in relation to underlying skeletal structures. They found that nose grows in a downward and forward direction from 1 to 18 years of age. He concluded that vertical growth continues until 16 years in females and 18 years in males. These were supported by Meng et al.[11] But, Genecov et al.[14] found that antero-posterior growth and increased anterior projection of the nose continued in both males and females after skeletal growth had subsided and the angular shapes and positional relationships of the nose, lips and chin remained relatively constant throughout the development. They also found no relationship between the amount of nasal development and skeletal class or sex of the subjects.

Our study was about the evaluation of the nostril shape in different skeletal pattern. Profile and basal photographs of 62 patients with skeletal Class I, 62 patients with Skeletal Class II with prognathic maxilla and 62 patients with Class III due to retrognathic mandible were evaluated. We could find significant association between different skeletal pattern and nostril inclination (P value -0.0001).

Mean degree of inclination in Class I skeletal pattern was 46.98±5.57⁰. In Class II skeletal pattern with prognathic maxilla mean degree of inclination was 55.32±4.9⁰. In Class III patients with retrognathic maxilla, mean degree of inclination was 37.63±4.37⁰. We could see that when the maxilla is retrognathic, inclination of the nostril decreased. When the maxilla is prognathic, the degree of inclination of the nostril increased. Thus, there is a strong association between the skeletal malocclusion and nostril inclination.

Our study shows that most common type of nostril in Class I skeletal pattern was Type III. Most common type of nostril among Class II skeletal pattern due to prognathic maxilla was Type II. Most common type nostril in Class III retrognathic maxilla was Type V. This shows the relation between the nostril and maxilla. Numerous studies show the relation of maxilla and nose.

Scott's[18] hypothesis says that the nasal septum is a primary center for midface growth. Latham[79] suggested that the nasal septum pulls the premaxillae and maxillae forward via septo-premaxillary ligaments. Grymer et al.[21] conducted a study on identical twins and found that deficient nasal septum growth along with decreased anteroposterior growth of the maxilla leads to an upward displacement of the anterior part of the maxilla. These studies indicate the strong relationship between nasal septum growth and maxillary growth.

Chaconas[13] studied the growth of the nose and its relationship to various morphogenetic dentoskeletal criteria, age, and sex. He concluded that the configuration of the dorsum of the nose in Class II subjects was convex. The Class I subjects had straighter noses, and the Class III subjects revealed a concave configuration of the nose. Similarly, Robison et al.[36] studied the association between nasal and skeletal parameters and concluded that nasal shape followed the underlying skeletal pattern very closely. They noted that patients with straight profiles tended to have straight noses; convex profiles had convex nasal shapes; and concave profiles were found with concave nasal shapes. Although the parameter used in our study were different from other studies, our study supports the findings of Chaconas[13], Robison et al.[36] that maxillary skeletal pattern has strong relation to the nose shape.

Contradicting to the above studies, Genecov et al[14] reported no relationship between the amount of nasal development and skeletal condition of the subjects. The growth observed was relatively independent of the underlying skeletal hard tissue.

Gulsen et al[5] conducted a study to evaluate the relationship between the facial skeletal and the nasal profile in Anatolian Turkish adults. He concluded that nasal length, prominence, and form are associated with height and length of the maxilla and the mandible. They also studied the relationship of the nasolabial angle with facial skeletal pattern and found no significant correlation between them. Thakur et al[69] conducted the same study in Himachal population. Results showed that nasal length and Nasal Depth showed positive correlation with the length of maxillary and mandibular jaws and facial height. Nasal hump, Nasolabial angle, Nasal base angle and Columella convexity showed no correlation with the underlying craniofacial structures. They concluded that nose is related to underlying craniofacial structures in Himachal adult population. They also concluded that all the parts of nose do not follow underlying craniofacial structures. Sahoo et al.[77] published a systematic review on relationship of nasal morphology with different dentoskeletal patterns. They concluded that the nose is found to be convex in skeletal class II, straight in class I, and concave in class III. Those with increased vertical growth may have an increased tendency of a convex nasal dorsum. Maxillary and mandibular jaw length affect the nasal parameters more than the jaw position. Nasal length and nasal depth increase with the jaw length and mandibular and maxillary/palatal-plane inclination to the cranium. A long nose with increased nasal depth is expected in long faces and those with long upper and lower jaws. An upturned nose is found with an anticlockwise-rotated maxilla.

All these studies shows that shape and size of the nose is related to the size of the maxilla except Genecov et al.[5] Our study also shows a similar result. Our study was about the relation of nostril to the maxilla. No investigation has ever been carried out to determine if a relationship exists between nostril inclination and sagittal maxillary skeletal pattern. Nostril being a part of the nose, a change in the nostril inclination will also affect the nose.

Knowing the ideal nostril angulation will help in diagnosis and treatment planning. It will also help in planning orthognathic surgery. Study by Olate et al[68] has shown that maxillary advancement can result in raising/ rotating the nasal tip, widening the alar base, and lowering the columella. Maxillary impaction can result in raising the nasal tip and upper lip, widening the alar base, and retracting the columella at the subnasal. Maxillary setback can result in widening the nasal bridge, an obtuse nasolabial angle, and decreased projection of the nasal tip, and maxillary down-fracture can result in inferior positioning of the alar base and columella, a droopy nasal tip, and an obtuse nasolabial angle.[88]

Similar study was conducted by McCollum et al.[57] They studied the sagittal soft-tissue changes related to the surgical correction of maxillary-deficient Class III malocclusions. They concluded that changes in the positions of hard- and soft-tissue landmarks for the nose, upper lip, lower lip, and chin area showed significant correlations for both horizontal and vertical movements of maxilla. Anterior nasal tip moves horizontally in a 0.26:1 ratio with upper incisor anteriors and 0.34:1 ratio with anterior nasal spine.

These studies show that, maxillary osteotomy changes the shape of the nose. Change in shape of nose depends on movement of the maxilla. Hence, when planning orthognathic surgery, nasal changes that accompany maxillary osteotomies should be considered. Patient should be informed about the risk of change in nose shape. Surgeon should consider its relative position and effect on the final result. In some cases, orthognathic surgery may change the harmony of the nose in relation to the face. These changes should be presented in the treatment plan.[80] By knowing the value of nostril inclination and nasal shape, it will help the surgeon to plan the rhinoplasty procedure and to plan the final shape of the nose.

It will also help in diagnosis of skeletal malocclusion. But, study by Ohki et al.[40] found statistically significant variation between racial groups and nasal width. They also showed that Caucasian noses were leptorrhine, Negro noses were platyrrhine, and Oriental noses were of intermediate dimension. The study by Morgan et al.[44] also concluded that race has a significant effect on acoustic rhinometry measurements. But, in our study racial difference was not considered. So, it cannot be considered as an average value for all population. Further study is required to find the value in different population.

Farkas et al.[33] assessed the standard nostril types in different population. Nostril type was assigned according to the inclination of the medial longitudinal axis of the nostrils and following the Topinard system for classification. They found that the most common nares were Type II in Caucasians (52.8%), Type III in Asians (52.8%), and Type VI in blacks (50.0%). This study shows the ethnic difference in nostril. Yet, we can see that most common type nostril is Type III. Our study shows that most common type nostril in Class I skeletal pattern is Type III. This result is comparable to that of Farkas et al.

There are so many studies which show the result similar to ours. But the parameters taken were different from all other studies except that of Farkas et al.[33] This study helps us to find the average inclination of nostril in different skeletal pattern. This serves as a supporting aid for the diagnosis of the skeletal condition of the patient. This also helps in rhinoplasty procedure to find the average inclination of the nostril for patient's profile.

Limitations of the study

- Although relation between inclination of the nostril and sagittal maxillary skeletal pattern was assessed in the study, the relation between the nostril and vertical skeletal pattern was not assessed in this study.

- Relation of nostril and mandibular skeletal pattern was not considered in this study.

- Racial difference and sex difference was not considered in this study

Future scope of the study

- Nostril inclination and vertical maxillary skeletal pattern can be studied to find the nostril inclination in different growth pattern

- It would be helpful to perform the same research in different population to find out average nostril inclination for different maxillary skeletal pattern.

Conclusion

CONCLUSION

From the results obtained from the study following conclusions were drawn:

Mean inclination of nostril is more acute in skeletal Class III patients. Inclination of the nostril increases with prognathism of maxilla. Most common type nostril found in Class I skeletal pattern was Type III. In Class II skeletal pattern due to prognathic maxilla, most common type nostril was Type II, whereas in Class III retrognathic maxilla, it was Type V. From this finding it can be inferred that there was a significant correlation between nostril inclination and maxillary skeletal pattern.

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Annexures

Annexure 1: Informed Consent (Malayalam)

<u>സമ്മതപത്രം</u>

സെന്റ് ഗ്രിഗോറിയസ് ഡെന്റൽ കോളേജിലെ, ഓർത്തോഡോണ്ടിക്സ് വിഭാഗം നടത്തുന്ന ക്ലാസ് വൺ 1, ക്ലാസ് 2, ക്ലാസ് 3 രോഗികളുടെ മൂക്കിലെ ദ്വാരത്തിന്റെയും മേൽ താടിയുടെയും പൊരുത്തക്കേട് വിലയിരുത്തുന്ന പഠനത്തിൽ മകൾ/മകന്............................ പങ്കെടുക്കാൻ എനിക്ക് സമ്മതമാണ്. പഠനത്തെക്കുറിച്ചുള്ള എല്ലാ വിവരങ്ങളും എനിക്ക് അറിയാവുന്ന ഭാഷയിൽ എന്നോട് വിവരിച്ചിട്ടുണ്ട്. ഏത് നിമിഷവും പഠനത്തിൽ നിന്നും പിന്മാറാം എന്നും, ഇത് തുടർന്നുള്ള എന്റെ മകളുടെ / മകന്റെ ചികിത്സയെ ബാധിക്കില്ലെന്നും, ചികിത്സാ വിവരങ്ങളുടെ സ്വകാര്യത നഷ്ടപ്പെടുത്താതെ സൂക്ഷിക്കുമെന്നും ഉറപ്പ് നൽകിയിട്ടുണ്ട്. ഇതിന്റെ ഭാഗമായി ഫോട്ടോ എടുക്കുന്നതിനും പ്രസിദ്ധീകരണങ്ങളിൽ പ്രസിദ്ധീകരിക്കുന്നതിനും എനിക്ക് സമ്മതമാണ്.

പേര്

ഒപ്പ്/വിരലടയാളം

രക്ഷകർത്താവിന്റെ പേര്

ഒപ്പ്/വിരലടയാളം

തിയതി

പരിശോധകന്റെ പേര് ഒപ്പ്

വിലാസം

സാക്ഷിയുടെ പേര്

ഒപ്പ്/വിരലടയാളം

ഡോക്ടർ..................................

പിജി വിദ്യാർത്ഥിനി

Annexure 2: Informed Consent (English)

INFORMED CONSENT

I ……………………………. aged …………year son/daughter of…………………………………………………. hear by give my consent to be part of the study "Evaluation of the nostril shape in skeletal class I, class II and class III patients with maxillary discrepancy: an In Vivo study "held at Department of Orthodontics St. Gregorios Dental college, Kothamangalam.

I have been informed in detail in the language known to me, about the study. My participation in the study is entirely voluntary & my decision not to participate will not have any negative effect on my dental care. I understand that my identity details will be kept confidential & I hereby grant permission /consent to Department of orthodontics & dentofacial orthopedics to take & use photographs & or digital images of me for use in dissertation& for academic publications.

Parent signature/Thumb impression with date:

Patients signature/Thumb impression with date:

Address :

Contact number :

WITNESS CERTIFICATE

1.

Annexure 3: MASTER CHART

NOSTRIL INCLINATION MEASUREMENT

	SI no	Inclination of nostril	Classification
Class I	1	43.7	Type III
	2	36	Type V
	3	44	Type III
	4	41.7	Type III
	5	48.6	Type III
	6	47.9	Type III
	7	46.9	Type III
	8	40	Type III
	9	41.4	Type III
	10	40	Type III
	11	35.8	Type V
	12	45.4	Type III
	13	40	Type III
	14	40.3	Type III
	15	46.6	Type III
	16	48	Type III
	17	43	Type III

Class I	18	46.8	Type III
	19	40.9	Type III
	20	45.45	Type III
	21	37.46	Type V
	22	57.3	Type II
	23	40	Type III
	24	50.2	Type III
	25	46.5	Type III
	26	51.7	Type III
	27	51.2	Type III
	28	57.8	Type II
	29	49.9	Type III
	30	43.45	Type III
	31	52.67	Type III
	32	53.6	Type III
	33	54	Type III
	34	43.8	Type III
	35	44.2	Type III
	36	48.8	Type III
	37	48.2	Type III
	38	52	Type III
	39	53.8	Type III
	40	49.8	Type III
	41	40.5	Type III

Class I	42	42	Type III
	43	53.4	Type III
	44	51.2	Type III
	45	51.8	Type III
	46	55.2	Type II
	47	49.6	Type III
	48	42	Type III
	49	48.47	Type III
	50	41.3	Type III
	51	49.9	Type III
	52	49.9	Type III
	53	52.9	Type III
	54	53.35	Type III
	55	50.8	Type III
	56	38.1	Type V
	57	51.8	Type III
	58	57.5	Type II
	59	41.9	Type III
	60	44.2	Type III
	61	51.7	Type III
	62	46.8	Type III
Class II	1	44.7	Type III
	2	57.9	Type II

Class II	3	57	Type II
	4	48.5	Type III
	5	50.5	Type III
	6	50.4	Type III
	7	51.7	Type III
	8	61.2	Type II
	9	58.2	Type II
	10	57.8	Type II
	11	50.6	Type III
	12	57.4	Type II
	13	50.4	Type III
	14	49	Type III
	15	58.56	Type II
	16	55.8	Type II
	17	56	Type II
	18	47.7	Type III
	19	56.4	Type II
	20	55.6	Type II
	21	49.5	Type III
	22	61.27	Type II
	23	46.2	Type III
	24	66.7	Type II
	25	57.6	Type II
	26	56.9	Type II

Class II	27	58.5	Type II
	28	48.57	Type III
	29	63.5	Type II
	30	57.6	Type II
	31	47.8	Type III
	32	66.65	Type II
	33	57.5	Type II
	34	70.27	Type I
	35	56.96	Type II
	36	55.6	Type II
	37	55.1	Type II
	38	55.3	Type II
	39	58.5	Type II
	40	52.6	Type III
	41	52.9	Type III
	42	56.2	Type II
	43	54.8	Type II
	44	56.35	Type II
	45	59.49	Type II
	46	54.09	Type III
	47	58.9	Type II
	48	47.6	Type III
	49	54.1	Type III
	50	54.9	Type II

Class II	51	51.05	Type III
	52	56.96	Type II
	53	60.32	Type II
	54	57	Type II
	55	56.9	Type II
	56	55.8	Type II
	57	47.41	Type III
	58	55.78	Type II
	59	52.4	Type III
	60	55	Type II
	61	55.6	Type II
	62	58.28	Type II
Class III	1	39.2	Type V
	2	37.7	Type V
	3	37.4	Type V
	4	46.6	Type III
	5	45.43	Type III
	6	39.3	Type V
	7	38.8	Type V
	8	44.9	Type III
	9	38.1	Type V
	10	36.7	Type V
	11	37.2	Type V

Class III	12	43.3	Type III
	13	37.5	Type V
	14	29	Type V
	15	41	Type III
	16	36.3	Type V
	17	38	Type V
	18	43.6	Type III
	19	25.3	Type V
	20	34.4	Type V
	21	38.9	Type V
	22	36.9	Type V
	23	44.6	Type III
	24	38.7	Type V
	25	46.8	Type III
	26	30.9	Type V
	27	29.6	Type V
	28	38.5	Type V
	29	39	Type V
	30	37.5	Type V
	31	39	Type V
	32	38	Type V
	33	39	Type V
	34	35	Type V
	35	32.9	Type V

Class III	36	41.4	Type III
	37	26.5	Type V
	38	38.3	Type V
	39	34.6	Type V
	40	39	Type V
	41	40	Type III
	42	35.7	Type V
	43	36.6	Type V
	44	37	Type V
	45	31.9	Type V
	46	34.5	Type V
	47	32	Type V
	48	43	Type III
	49	38.5	Type V
	50	39	Type V
	51	37.5	Type V
	52	40.5	Type III
	53	37.2	Type V
	54	34	Type V
	55	37.4	Type V
	56	36.9	Type V
	57	44.2	Type III
	58	36.2	Type V
	59	34.5	Type V

Class III	60	38.7	Type V
	61	35.2	Type V
	62	37.9	Type V

ST. GREGORIOS DENTAL COLLEGE

UNDER THE MANAGEMENT OF MJSCE TRUST, PUTHENCRUZ

CHELAD , KOTHAMANGALAM, ERNAKULAM DIST, KERALA - 686681

ETHICAL CLEARANCE CERTIFICATE

SGDC/152/2022/4343 24/05/2022

To,

Dr.Vidya S L
St. Gregorios Dental College
Chelad, Kothamangalam

Subject: **Ethics Committee Clearance - reg.**

Protocol: Evaluation of the nostril shape in skeletal class I, class II and class III patients with maxillary discrepancy: An In Vivo study.

After the Institutional Ethics Committee (IEC) held on 24th of May 2022, this study was examined and discussed. After the consideration, the committee had decided to approve and grant clearance for the aforementioned study.

The members who attended the meeting at which the protocol was discussed were:

1) Dr.C.K.K Nair - Former BARC Scientist.
2) Dr.Cinu Thomas A - Scientist, Senior lecturer, Department of Pharmaceutical Sciences Centre for Professional and Advanced Studies.
3) Dr.Lissy Jose - Former member Women's Welfare Association.
4) Adv.Jose Aranjani - Advocate.
5) Dr.Sauganth Paul - Reader, Department of Biochemistry, St.Gregorios Dental College.
6) Dr.Eapen Cherian - Secretary.
7) Dr.Jain Mathew - Principal and Head of the Department, Department of Conservative Dentistry and Endodontics.
8) Dr.George Francis - Head of the Department, Department of Prosthodontics and Crown & Bridge.
9) Dr.Binnoy Kurian - Head of the Department, Department of Orthodontics & Dentofacial Orthopaedics.

Dr. C.K.K Nair
Chairman Institutional Ethics Committee
St.Gregorios Dental College, Chelad

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Annexure 5: ACKNOWLEDGEMENT

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Dr. VIDYA S.L.

LIST OF ABBREVATIONS

Sl.no	Abbreviation	Full form
1.	CBCT	CONE BEAM COMPUTED TOMOGRAPHY
2.	DSLR	DIGITAL SINGLE LENS REFLEX
3.	JPEG	JOINT PHOTOGRAPHIC EXPERTS GROUP
4.	LNLA	UPPER LIP INCLINATION
5.	MA	MAXILLARY ADVANCEMENT
6.	MAI	MAXILLARY ADVANCEMENT WITH IMPACTION
7.	NB	NASAL BREADTH
8.	NBL	NASAL BONE LENGTH
9.	NH	NASAL HEIGHT
10.	NLA	NASOLABIAL ANGLE
11.	NTP	NASAL TIP ANGLE
12.	UNLA	NASAL UPWARD TIP ANGLE