# The Position of Glenoid Fossa in Different Skeletal Patterns and Its Relation to the Functional Occlusal Plane

**A thesis**

**Submitted to the council of the College of Dentistry University of Baghdad, in Partial Fulfillment of the Requirements for the Degree of Master in Science in Orthodontics**


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بسم الله الرحمن الرحيم

اقرأ باسم ربك الذي خلق * خلق الإنسان من علق * اقرأ وربك

الأكرم * الذي علم بالقلم * علم الإنسان ما لم يعلم*

صدق الله العظيم

سورة العلق، الآية ١-٥

# Declaration

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# Dedication

## To My Family with Love

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# Abstract

Glenoid Fossa position plays an important role in the establishment of different craniofacial patterns.The purpose of this study was to verify the position of the glenoid fossa in subjects with different sagittal and vertical skeletal patterns, to assess the correlation between the position of Glenoid Fossa and skeletal patterns (sagittal and vertical), and to assess the correlation between the position of the glenoid fossa and the functional occlusal plane.

A lateral cephalometric study was carried out on 124 subjects aged 18-30 years who were classified according to skeletal sagittal relationships using ANB angle into three groups (Cl. I =48, Cl. II =41, Cl. III =35 subjects), and according to skeletal vertical relationships using MP-SN angle into three groups (normal angle=67, high angle=23, low angle=34 subjects). Cephalometric analysis comprised both sagittal and vertical measurements for the assessment of the position of the glenoid fossa in relation to surrounding skeletal structures. The assessment was achieved by measuring three angular and seven linear variables using the AutoCAD computer program 2008.

The results revealed that in sagittal skeletal relation, the glenoid fossa position was more posterior in skeletal Class II when compared with skeletal Class III, while in the vertical plane; the position of the glenoid fossa relative to Basicranial structures was more caudal in low angle subjects when compared with subjects with normal or high angle vertical relationships. On the other hand, there was no correlation between the position of the glenoid fossa and the functional occlusal plane.

In conclusion, subjects with high angle vertical relationships show a more cranial position of the Glenoid Fossa in relation to cranial base when compared to subjects with either normal or low angle vertical relationships regarding the vertical plane and there is no valuable diagnostic information from the functional occlusal plane in relation to the position of the glenoid fossa.

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# List of Abbreviations

| | |
|---|---|
| AutoCAD | Auto Computer Aided Design |
| Cl. | class |
| d.f. | Degree of Freedom |
| FOP | Functional occlusal plane |
| GF | Glenoid Fossa |
| I.U.L | Intrauterine life |
| kV | Kilovolt |
| mA | milliamperage |
| mm | Millimeters |
| N | Number of the sample |
| No. | numbers |
| P-values | Probability values |
| SPSS | Statistical Packages for Social Sciences |
| TMJ | Temporomandibular Joint |

# Introduction:

The relationship of the mandible to the cranial base influences both sagittal and vertical facial disharmony. Glenoid fossa position is likely to play an important role in the establishment of different craniofacial patterns. The literature provides only limited data about the diagnostic significance of the position of the temporomandibular joint in relation to other skeletal structures (**Hopkin et al., 1968; Droel and Isaacson, 1972; Kantomaa, 1989**). On the contrary, many experimental and clinical contributions have demonstrated the effects of orthopedic/orthodontic therapies on glenoid fossa position and morphology (**Stockli and Willert, 1971; Elgoyhen et al., 1972; Pancherz, 1979; Birkebaek et al., 1984; Agronin and Kokich, 1987; Woodside et al., 1987; Paulsen et, al; 1995**).

In particular, **Pancherz** (**1979**) described the forward displacement of the articular portion of the temporal bone following Herbst therapy of classII malocclusion. **Woodside et al.** (**1987**) observed similar changes in glenoid fossa of primates whose mandibles had been forced into protrusion by means of orthodontic appliances. It should obviously be stressed that therapeutically-induced glenoid fossa displacement is partly due to concomitant physiological growth and remodeling of surrounding structure (**Baumrind et al., 1983**).

Remodeling of the bone is the selective bone apposition by osteoblasts and resorption by osteoclasts. Although these changes may occur simultaneously in the same bone, they are not necessarily equal in amount or opposite in direction. This results in differential changes and alterations in the size as well as the morphology (shape) of a given bone **(Bishara, 2001)**.

Radiographs may be used to gain information about the status of the temporomandibular joint by revealing morphologic information about the position of glenoid fossa and its relationship to the base of the skull. Various radiographic techniques have been advocated for the evaluation of the temporomandibular joint **(Eckerdal & Lundbergh, 1979)**.

A clinical and radiographic study was carried out by **Samerjian** (**2009**) who used lateral and posteroanterior cephalometric views to demonstrate the effect of Hyrax and Cl.II elastics on the glenoid fossa and its importance in orthodontic field.

This study is the first in Iraq to deal with the position of glenoid fossa in relation to different skeletal discrepancies and correlate it with the functional occlusal plane by using Lateral cephalometric view.

# Aims of the study

- To determine the position of glenoid fossa in sagittal and vertical planes in relation to cranial base in different sagittal and vertical skeletal patterns.

- To find if there is any correlation between position of glenoid fossa and sagittal and vertical skeletal patterns.

- To find if there is any correlation between position of glenoid fossa and functional occlusal plane.

# CHAPTER ONE

# 1. Review of literature

## 1.1. Growth and Development

**Bishara and Ferguson (2001)** stated that the terms growth, development, and maturation are often used interchangeably to describe the changes that occur throughout life. They defined growth as size development, progressive development (i.e. evolution, emergence, increase or expansion), and development as going through natural growth, differentiation, or evolution by successive changes, while maturation as the emergence of personal characteristics and behavioral phenomena through growth processes. On the other hand, **Proffit et al. (2007)** stated that the term growth usually refers to an increase in size or number while the term development refers to an increase in complexity.

### *1.1.1. Cranial base:*

The cranial base is made up mainly of cartilage replacing bones, the external and basi-occipitals, the body, lesser wings and part of the greater wings of the sphenoid, the petrous part of the temporal bones, and the perpendicular plate of ethmoid **(Scott and Symons, 1982)**.

**Salzmann (1966)** stated that the cranial base can be divided into three segments. These are:

1. The posterior segment from Basion to Sella.
2. The middle segment from Sella to foramen caecum.
3. The anterior segment from foramen caecum to Nasion.

#### *1.1.1.1. <u>Prenatal Growth and Development of cranial base</u>*

The base of skull is first formed in the embryo in cartilage **(Mills, 1983)**. The cartilage, from which the chondrocranium develops, begins to form at about the seventh week of intrauterine life (I.U.L). At the end of the third month the chondrocranium consists of a mass of cartilage shaped like a capsule. A number of ossification centers in the cartilage show themselves, and finally form the cranial base. The centers of ossification in the cranial base are the basisphenoid, the occipital, and later the ethmoidal and presphenoidal centers. These appear between the fifty-fifth and eighty-third days. They give rise to the basicranial synchondroses **(Salzmann, 1966)**.

The cartilage junctions between two bones are called synchondroses. New cartilage cells continually form in the center of the synchondrosis, move peripherally, and then undergo endochondral ossification along the lateral margins. The occipital bone is formed first, followed by the body of the sphenoid bone and then the ethmoid bone **(Avery, 1994)**. Prenatally, the cranial base has a series of synchondroses within and between the ethmoid, sphenoid, and occipital bones. This arrangement allows for a rapid increase in the length of the cranial base early in life to accommodate the growing brain **(Bishara and Ferguson, 2001)**.

#### *1.1.1.2. Postnatal Growth and Development of cranial base*

All three mechanisms of bone growth play their parts in enlargement of the cranial base **(Foster, 1985)**:

1. **Cartilaginous growth**

The cranial base grows primarily by cartilage growth in the sphenoethmoidal, intersphenoidal, spheno-occipital and intraoccipital synchondroses. The intraethmoidal and intersphenoidal synchondroses close before birth, whereas the intraoccipital synchondrosis closes before 5 years of age. The sphenoethmoidal synchondrosis closes around 6 years of age, and the segment of the anterior cranial base designated as the planum sphenoidale becomes relatively stable early in life **(Knott, 1971; Graber, 1988)**.

The spheno-occipital synchondrosis is of special interest as it makes an important contribution to growth of the cranial base during childhood, continuing to grow until about 15 years of age and fusing at approximately 20 years **(Carter, 2004)**.

The direction of growth in the spheno-occipital synchondrosis is along an axis which is directed forwards and upwards. It therefore carries the upper part of the face and the anterior half of the base of the cranium bodily upwards and forwards. This upward movement is compensated by downward growth of the face itself **(Gardiner et al., 1998)**.

2. ***Sutural Growth***

**Scott (1957)** reported that at the base of the skull the sagittal suture system is divided so as to run on either side of the midline cranial base; it is made up of the following parts, from front to back:

a) The metopic frontal suture as far back as the foramen caecum.

b) The region of the cribriform plate.

c) At the back of the orbital cavities the body of the sphenoid forms the medial walls of each cavity beneath the outward-spreading lesser wings which form the roof of each orbital cavity.

d) The greater wings of the sphenoid, which ossify in membrane, are separated from the body of the bone by an area of cartilage.

e) The temporal bones (petrous parts) are separated from the side of the body of the sphenoid and of the occipital bone by connective tissue and the jugular foramen.

During the first year after birth, the metopic suture, in the vast majority of skulls, commences to unite so that the two halves of the frontal bone become continuous. At the same time, the greater wings become united to the body of the sphenoid. Soon afterward (by the third year) the cribriform plate ossifies from side to side, uniting the facial part of the ethmoid to the mesethmoid (perpendicular plate) **(Scott, 1957)**.

The greater wings of the sphenoid and squamous part of the occipital bones are separated by the wedge-shaped petrous portions of the temporal bones. Growth at these obliquely placed sutures contributes to increases of width and length of the cranium. The sutures between the sphenoid and frontal and ethmoid bones are also important cranial growth sites up to the age of eight years **(Gardiner et al., 1998)**.

### 3. The surface Remodeling

Growth of the anterior part of the cranial base is still necessary after the brain has virtually ceased to grow, at 7 to 8 years, in order to allow for facial growth. This growth takes place almost entirely by increased pneumatization of the frontal and ethmoid bones **(Ford, 1958)**.

The remodeling of the cribriform plate is usually terminated around the age of four. On the other hand, the planum sphenoidale, the chiasmatic sulcus and the tuberculum sellae are sites of appositional growth up to the ages of 13-16. The internal contour of the sella turcica was found to be the site of a differentiated growth pattern, with continued resorption of the posterior part of the floor and of the posterior wall until the ages of 15 in females and 17 in males, whereas the anterior wall of the sella turcica usually showed no remodeling change after the age of five (Figure1.1). The cerebral surface of the basioccipital bone showed continued resorption up to the age of 17 in females and 19 in males while the external, pharyngeal surface showed continuous apposition in the same period **(Melsen, 1974)**.

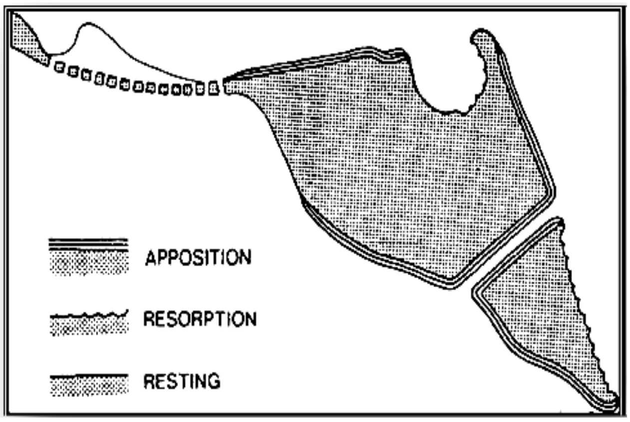



Figure1.1. Remodeling of cranial base after age 7 year **(Melsen, 1974)**

## 1.2. Condylar Growth and development

The term "Development" carries a physiologic and a behavioral Phenomenon where it is an increased complexity of organization and an increase in the specialization. The term "growth" referred to the increase in the number and the size of the organ component **(Moyers, 1988; Proffit, 2000)**.

### *1.2.1. Condylar formation*

Mandible develops as several units, condyle unit forms the articulator, the body forms the center of all growth of mandible, the angular unit forms in response to the lateral pterygoid and masseter muscles .The development of the alveolar process forms in response to the teeth (**Avery, 1992**).

Condyle is the rounded cartilage and bone-articulating element in the mandible. It is the superior portion of the ramus that articulates with the temporal eminence in the glenoid fossa **(Marshall, 1990; Glossary 2002)**.

### *1.2.2. Condylar development*

At the sixth week of I.U.L, the mandible is developed as a thin rod of cartilage, the condyles are located at a region far away from the mid line **(Bhaskar, 1980)**. The primary cartilage disappears and a new one is formed which differs from the original one in its behavior, histological appearance and the intercellular matrix, it is called "secondary cartilage" which appears at the 12th week and persists till the second decade of life **(Scott and Simons, 1982; Davis, 1986)**.

In the I.U.L. from (12-19) weeks the mandible grows faster in width than in length or height to accommodate the base of the skull with which it is articulated **(Houpt, 1979)**. Growth is rapid in infancy and continuing steadily until 12 years **(Graber and Swain, 1985)**. Growth rates decrease during childhood and increase during adolescence **(Buchang et al, 2001)**.

### *1.2.3. Growth of the Condylar Cartilage and Its articular function*

Cartilaginous maturation, which is characterized by chondrocyte hypertrophy, leads to the transition of chondrogenesis into osteogenesis (endochondral ossification). It is therefore safe to contend that condylar unloading stimulates condylar growth, while articulating function, in contrast, slows condylar growth. This contention is in agreement with the statement that when articulating function is not present in the mandibular jaw joint, the cartilage matures and is replaced by bone. **(Kantomaa and Hall, 1991).**

#### *1.2.3.1. Condylar Cartilage Growth Pattern*

This cartilage was identified as the functional matrix **(Moss, 1960, 1962)**. At each upper end of the mandible a cap of cartilage represents the condyle and merges into the ramus. These two caps are centers from which growth occurs **(Tully and Campbell, 1970)**.

The condylar cartilage, which persists till the second decade of life, is responsible for the growth in the anteroposterior and the length of the mandible **(Salzman, 1966; Scott and Simons, 1982)**.

The characteristics of cartilage make it a most appropriate tissue for performing two very important functions in the body:

1. The capacity of cartilage to produce a strong, but flexible provisional supportive framework at a relatively high rate of growth fulfills a crucial function during embryonic and postnatal growth.
2. The chemical and physiological properties of the matrix components give cartilage resilience, a property, which is well suited to cushion compressive forces in loaded articular joints. These functions influence the development and determine the ultimate shape and composition of the mandibular condyle **(Copray et al, 1988)**.

### 1.2.3.2. Direction of Condylar Growth

The mandibular growth depends on the relative rate of growth in the condylar, sutural and alveolar regions. If the growth in condyle is in equilibrium with the growth in the facial sutures and alveolar growth, the result is parallel growth displacement (downward and forward displacement) (Fig 1.2), involving no rotation. If more growth in the outer region (facial sutures and alveolar process), the mandible is posteriorly positioned (vertical growth displacement), while if more growth in the condylar region this will lead to forward rotation (Horizontal growth direction) (**Schudy, 1965; Bjork, 1969; Rakosi, 1982; Buchang and Gandini, 2002**).

The active condylar growth is more effective in the ramus height than in the growth of the body of the mandible (**Baregg et al., 1995; Bishara, 2000**). The growth of the condyles is compensated by the vertical displacement of the mandible to accommodate the eruption of the teeth vertically (**Enlow and Harris, 1964; Sarnat, 1986**).

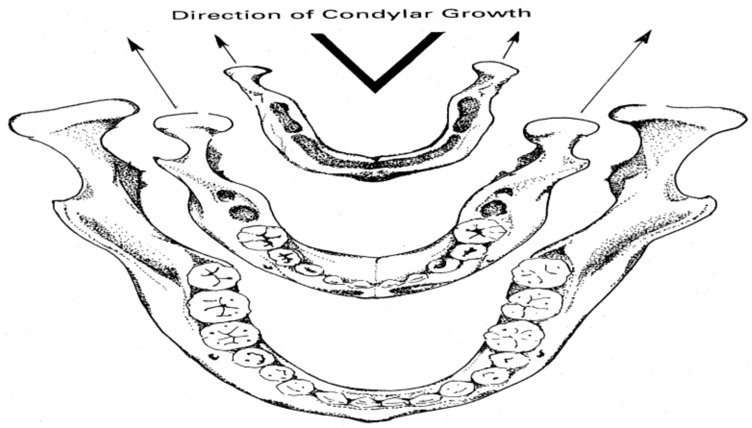



Figure1.2. Mandibles of a neonate (top), a 4-year-old child (middle), and an adult (below), illustrating the constant width of the anterior body of the mandible as opposed to the lateral expansion of the rami with growth, indicated by arrows and the "V." (**Sperber, 2001**).

It is important to separate condylar growth into its component parts, vertical and horizontal, because they have different functions. Vertical condylar growth has the function of moving the gonial angle downward and the chin forward, While horizontal growth only moves the chin forward (**Kim and Nielsen, 2001; McNamara et al, 2001**).

## 1.3. Articular Eminence Development

**Humphreys (1932)** thought that the eminence remains rudimentary until age seven, eventually assuming a mature appearance by age twelve. **Wright (1968)** concluded that the developing eminence had achieved a mature "S" shape by the age of two and one-half years. (fig 1.3)

**Oberg et al. (1971)** reported that the eminence dose not become well-defined until between the ages of five and eight years. **Wright and Moffett (1974)** and **Thilander et al. (1976)** described the postnatal development of the temporomandibular joint (TMJ) eminence in humans. These authors describe an eminence, rudimentary at birth, which develops before and during the time of eruption of the primary dentition.

The neonatal TMJ is characterized by highly vascular joint components. The temporal portion is quite rudimentary, with a shallow fossa and absence of an eminence. The region anterior to the future eminence and the region of the glenoid fossa are areas of typical intramembranous bone formation. Osteogenesis in the area of the eminence articulation, unlike intramembranous ossification, is promoted by a secondary cartilage which produces a "chondroid bone" (**Beresford, 1981**).

The chondroprogenitor layer of the temporal chondroid bone has been identified as the undifferentiated mesenchymal layer of the articular tissues (**Dale et al., 1963; Hall, 1970**).

The rate of development of the eminence reduces at about 5years of age, and slowly diminishes, stopping by the middle to late teens. This early development of the eminence reflects the changes in the direction of joint loading. This is due to condylar growth, transition from sucking to chewing, and variation in the three-dimensional orientation of the musculature caused by growth of the craniofacial complex (**Palla**, **2004**)

## 1.4. Functional anatomy

### *1.4.1. Temporomandibular joint*

The TMJ articulation is a joint that is capable of hinge-type movements and gliding movements. The bony components are enclosed and connected by a fibrous capsule. The mandibular condyle forms the lower part of the bony joint and is generally elliptical, although variations in shape are common **(Yale et al., 1966)**. The articulation is formed by the mandibular condyle occupying a hollow in the temporal bone (glenoid fossa) (fig.1.3).

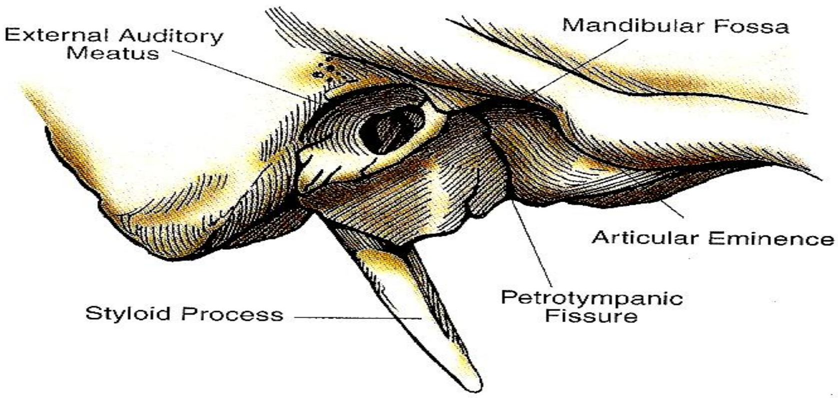



Figure1.3 The S- shape form of the fossa and eminence (**Blasberg and Greenberg 2008).**

The S- shape of the fossa and eminence develops at about 6 year of age and continues into a second decade (**Wright and Moffett, 1974**). During wide mouth opening, the condyle rotates around a hinge axis and glides, causing it to move beyond the anterior border of the fossa, identified as articular eminence (**Muto et al., 1994**).

The capsule is lined with synovium and the joint cavity is filled with synovial fluid. The synovium is avascular connective tissue lining the fibrous joint capsule and extending to the boundaries of the articulating surfaces. Both upper and lower joint cavities are lined with synovium **(Nazawa-Inoue et al., 2003)**.

The synovial tissue functions to produce synovial fluid, which acting as a lubricant, lowers friction between surfaces, removes degradation products from the joint space, and provides nutrition to the avascular regions of the articular surfaces and the disk. The amount of synovial fluid in the TMJ is usually so small, that cannot be aspirated, usually only a thin lining on the articular surfaces. Larger amounts of joint fluid usually are associated with painful internal derangement **(McMinn et al., 1991).**

The TMJ has a rigid end point determined by tooth contact. Rotation of the condyle contributes more to normal mouth opening than translation (**Ferraro et al., 2005**).

### *1.4.2. Articular Disc:*

A fibrocartilage made up primarily of dense collagen of variable thickness and referred to as a disc occupies the space between the condyle and mandibular fossa.(fig1.4).

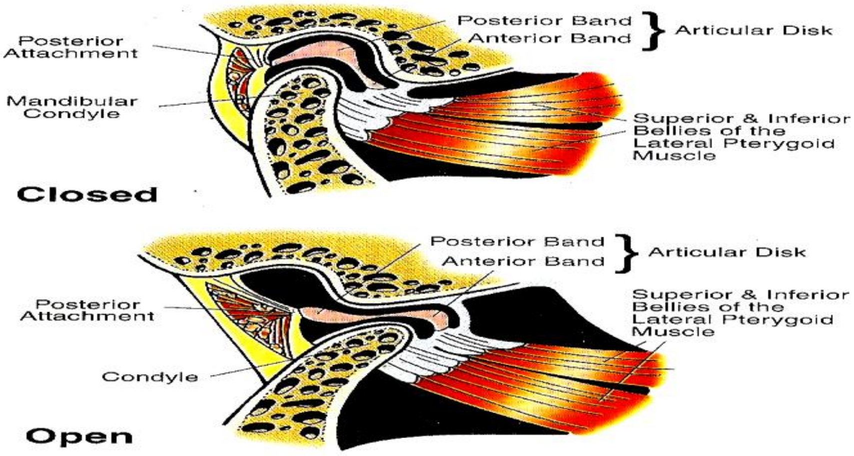



Figure1.4 TMJ is capable of hinge-type and gliding movements.The articular disc has ligamentous attachments to the mandibular fossa and condyle.The disc Attachments create separate superior and inferior joint compartments **(Blasberg and Greenberg, 2008).**

The disc consists of elastic (**Griffin and Sharpe, 1962**) and collagen fibers,and cartilage like proteoglycans (**Granstrom and Linde, 1973**).

The joint is divided by the interpositioned disc into upper and lower joint compartments, which normally do not communicate. The disc is a flexible but firm plate of dense collagenous connective tissue that merges around its periphery with the surrounding capsule. In the sagittal plane, the disc is biconcave; that is, it is thickest anteriorly and posteriorly. The thickness of the disc is 1mm in its central part, 3 mm posteriorly, and 2 mm anteriorly**,** the under aspect of the disc is concave and fits on top of the rounded condyle. The peripheral attachment to the capsule binds the disc firmly to the lateral and medial poles (sides) of the condyle. Anteriorly there is no direct connection between the disc and the mandibular condyle. Thus, the disc can rotate relatively freely over the condyle in an Antero-posterior direction, but it can move relatively little in the mediolateral direction, unless the attachments to the capsule and condyle have been torn or elongated. Anterior movement of the disc is limited by the length of the undersurface of the posterior disk attachment. This extends from the posterior band of the disc down to the back of the condyle and prevents the disk from moving anteriorly over the condyle **(Hansson andNordstrom, 1977; Katzberg and Westesson, 1993)**

There is a great variation in the configuration of the disc; generally its shape is well adapted to the shape of the condyle and the temporal component. In joints with deep fossae, the posterior band is usually thick and pronounced**,** whereas in joints with flat or shallow fossae the disc is more even in thickness. Blood vessels and nerves are absent in the disc but are frequent in its peripheral attachment to the capsule **(Katzberg and Westesson, 1993)**.

### *1.4.3. Temporomandibular ligaments (Fig.1.5).*

- ***Capsular ligament***
- ***Lateral temporomandibular ligament***
- ***Stylomandibular ligament***
- ***Sphenomandibular ligament***

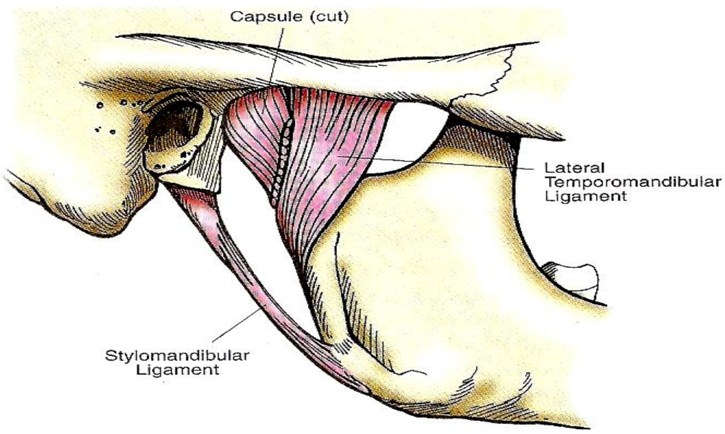
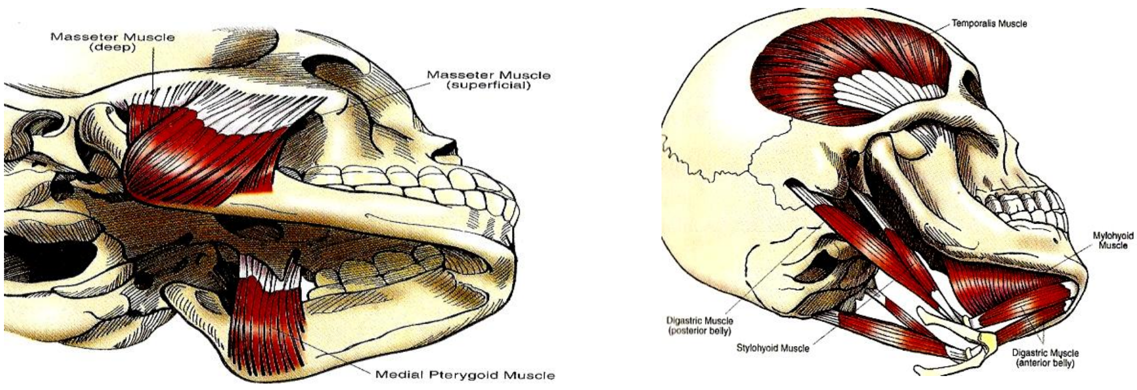



Figure1.5. The Temporomandibular ligaments **(Blasberg and Greenberg, 2008).**

### *1.4.4. Muscles of Mastication:*

The muscles of mastication are the paired masseter, medial and lateral pterygoid, and temporalis muscles and supplementary muscles include Digastric, mylohyoid and geniohyoid (figures1.6 and 1.7). Mandibular movements towards the tooth contact position are performed by contraction of masseter, temporalis, and medial pterygoid muscles. *Masseter* contraction contributes to moving the condylar head toward the anterior slope of the mandibular fossa. The posterior part of temporalis contributes to mandibular retrusion. Unilateral contraction of *medial pterygoid* contributes to a contralateral movement of the mandible. The Masseter and medial muscles have their insertions at the inferior border of the mandibular angle. They join together to form a sling that cradles the mandible and produces the powerful forces requried for chewing. The Masseter is divided into deep and superficial parts **(Blasberg and Greenberg, 2008)**.

*The temporalis muscle* is broadly attached to the lateral skull and has been divided into anterior, middle and posterior parts. The muscle fibers converge into a tendon that inserts on the coronoid process and anterior aspect of mandibular ramus. The anterior and middle fibers are generally oriented in a straight line from their origin on the skull to their insertion on the mandible. The posterior part traverses anteriorly and then curves around the anterior root of the zygomatic process before insertion **(Blasberg and Greenberg, 2008)**.




(A) (B)

Figure1.6 The masseter and medial pterygoid muscles (A), the temporalis, digastrics, Mylohyoid, and stylohyoid muscles (B) **(Blasberg and Greenberg, 2008).**

*The lateral pterygoid* is arranged in parallel-fibered units, whereas the other muscles are multi-pennated. This arrangement allows greater displacement and velocity in the lateral pterygoid and greater force generation in the elevator muscles (**Van Eijden et al., 1997**). The lateral pterygoid is the main protrusive and opening muscle of the mandible. The inferior head is the main section responsible for the lateral jaw movements when the teeth are in contact (**Huang et al., 2005**).

*The lateral pterygoid muscle* arises from two heads (fig1.7) . The inferior head arises from the outer surface of the lateral pterygoid plate of the sphenoid and pyramidal process of the palatine bones. The inferior head is thought to be active in opening and protrusive movements (**Lipke et al, 1977; Wilkenson, 1988**) and the superior head originates from the grater wing of the sphenoid and the pterygoid ridge **(Carpentier et al., 1988).** It's thought to be active during closing movement. Translation of the condylar head onto articular eminence is produced by contraction of the lateral pterygoid.

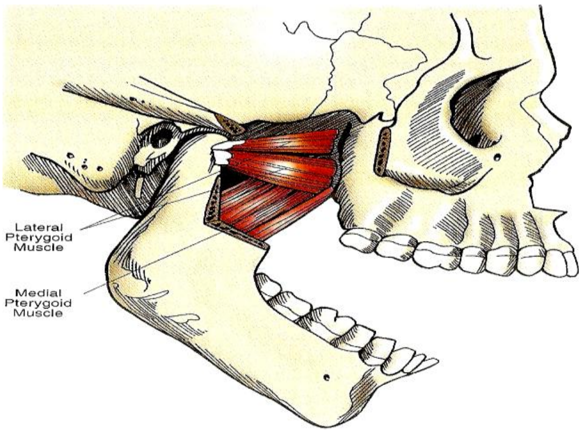



Figure1.7 The lateral and medial pterygoid muscles. **(Blasberg and Greenberg, 2008).**

*The digastric muscle* is a paired muscle with two bellies. The anterior belly attaches to the lingual aspect of the mandible at the parasymphesis and courses backward to insert to the hyoid bone. Contraction produces a depression and retropositioning of the mandible. The mylohyoid and geniohyoid muscles contribute to depressing the mandible when the infrahyoid muscles stabilize the hyoid bone (**Blasberg and Greenberg, 2008**).

## 1.5. Clinical Anatomy

### *1.5.1. Occlusion*

It is defined as when the maxillary and the mandibular teeth come in contact simultaneously when the condylar processes are fully seated in the mandibular fossa and the teeth do not interfere with harmonious movement of the mandible during function, (**Schweitzer, 1963**). This means that the teeth are in a maximum intercuspation, which means that the maxillary lingual and mandibular buccal cusps of the posterior teeth are in evenly distributed and stable contact with the opposing occlusal fossae (**Grant et al., 1982; Rosenstiel et al., 2001**).

Occlusion simply means the contact between the teeth when the mandible is closed and stationary (static occlusion), and those contacts between teeth when the mandible is moving relative to the maxilla (dynamic occlusion) **(Davies et al., 2001)**.

### *1.5.2. Normal Occlusion*

It was described as an occlusion within the accepted deviation of the ideal; it includes minor variations in the alignment, which are not of esthetic or functional importance (**Jones and Oliver, 2000**).

**Angle(1899)** stated that it is “the arrangement of the occlusal contact of the first permanent molars, the mesiobuccal cusp of the maxillary first permanent molar occluding with the buccal groove of the opposing mandibular first permanent molar, and the teeth were arranged in a smoothly curving line of occlusion” (**Ackerman and Proffit, 1969; Proffit, 2000**).

### *1.5.3. Rest Position*

When the mandible is not functionally active, it adopts a rest position in which the condyle occupies a relatively central position in the glenoid fossa with the teeth separated. The rest position is associated with minimum muscular activity, with the lower teeth a few millimeters from occlusal contact position

(**Michelotti et al, 1997**). The position varies for a number of reasons (including head posture and levels of muscle activity) and is not an exact position (**Woda et al., 2001**).

### *1.5.4. Centric Relation*

Centric relation is a position that has traditionally relied on guiding the condyles into a position to rotate around a stationary axis in the mandibular fossa. The definition stated in the "The Glossary of Prosthodontic terms" is "maxillomandibular relationship in which each condyle articulates with the thinnest a vascular portion of the disc in an anterosuperior position against the posterior slope of articular eminence." (**Glossary, 1999**).

### *1.5.5. Range of Mandibular Movement*

Mandibular motion is composed of translation and rotation of the condyles. During translation, the disc and condyle move downward and forward along the posterior slope of the articular eminence. The average rotation of the condyle is $42^{o}$ and the condylar translation between 13 and 15 mm for maximum opening (**Gallo et al., 1997**).

The articular disc translates with the condyle, but its movement is limited to a range of 5 to 9 mm (**Schmolke and Hugger, 1999**).

At maximum mouth opening, the condyles move to the crest of the articular eminence or beyond. A wide variation in mandibular movement exists. Incisor displacement remains the most common diagnostic indicator (**Dworkin and LeResche, 1992**). The temporomandibular, sphenomandibular and stylomandibular ligaments, together with the articular eminence have been suggested as the main constraints of jaw opening (**Osborn, 1993**). Muscular constraint of jaw opening has also been proposed as a significant contributing factor (**Peck, 1999**).

### *1.5.6. Articular covering*

The fibro-cartilage found on articulating surfaces of the TMJ is thought to provide more surface strength against forces in many directions while allowing more freedom of movement than would be possible with hyaline cartilage. Fibro-cartilage also forms the articular disc. This covering is thickest on the posterior slope of the articular eminence and on the anterior slope of the condylar head; these are the areas thought to receive the greatest functional load. The thinnest part of fibrocartilage covering is on the roof of the mandibular fossa. It has a greater repair capacity than hyaline cartilage. This may affect how the TMJ responds to degenerative changes (**Meikle, 1992**).

## 1.6. Articulation of glenoid fossa

In the newborn the glenoid fossa is very shallow (almost flat) and develops rapidly during the first years of life, it reaches about half its final shape by the time the eruption of primary dentition is completed (**Palla, 2004**)

TMJ is the articulation formed at the point where the mandibular condyle articulate with the articular tubercle of the temporal bone anteriorly and the mandibular fossa posteriorly (see fig 1.8) (**McKenly and OLoughlin, 2006**).

Articulation occurs between the articular tubercle and the anterior portion of mandibular fossa of the temporal bone (above), and the head (condyloid process) of the mandible (below) (**Snell, 2008**).

The temporal component of the TMJ consists of the concave glenoid (mandibular) fossa and the convex articular tubercle, both formed by the squamous part of the temporal bone.The temporal part of the joint measures, using capsular attachments as the margins, about 23 mm both in mediolateral width and in anteroposterior length. The depth of the fossa was reported by Moffet to average 7 mm when measured from the highest point in the fossa to the lowest point of the articular eminence (**Moffet, 1968**).The periosteum lining these articular surfaces is gradually transformed during its early development into the dense fibrous articular tissues of the TMJ, and articular forces acting through the TMJ play an important role in this gradual transformation. Articular forces also continue to play a major role in the development of these tissues well into adult life (**Bouvier and Hylander, 1982**).

Frequently the names glenoid fossa, mandibular fossa and articular fossa are used interchangeably.The glenoid, or mandibular, fossa is the concavity within the temporal bone that houses the mandibular condyle. Its anterior wall is formed by the articular eminence of the squamous temporal bone and its posterior wall by the tympanic plate, which also forms the anterior wall of external acoustic meatus. The bony roof of glenoid fossa is quite thin and often appears translucent when held against the light. This is but one indication that the roof of this fossa is not a major stress-bearing portion of the TMJ (**Hylander, 1992**).

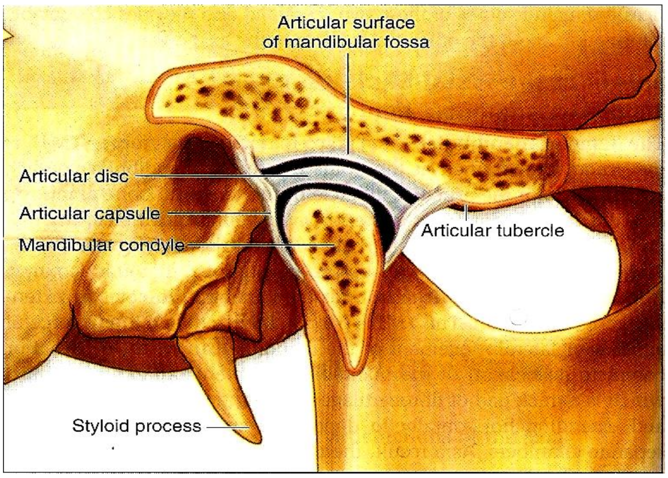



Figure1.8 TMJ. The articulation between the condylar process of the mandible and mandibular fossa of temporal bone **(McKenly and OLoughlin, 2006)**.

The articular surface is that portion of the glenoid fossa that is lined by articular tissues. It is formed entirly by squamous temporal bone (fig1.8and 1.9).The posterior part of the articular fossa is elevated to a ridge called the posterior articular lip. In most individuals the posterior articular lip is higher and thicker at its lateral end and thus is seen from the side as a cone-shaped process between the articular fossa and tympanic plate. This structure is the postglenoid process. The lateral border of the articular fossa is sometimes marked by a narrow, low ridge. Medially, the articular fossa is bounded by a bony plate that leans against the spine of the sphenoid bone (fig1.9). This medial plate is sometimes drawnout into triangular process called the temporal spine.

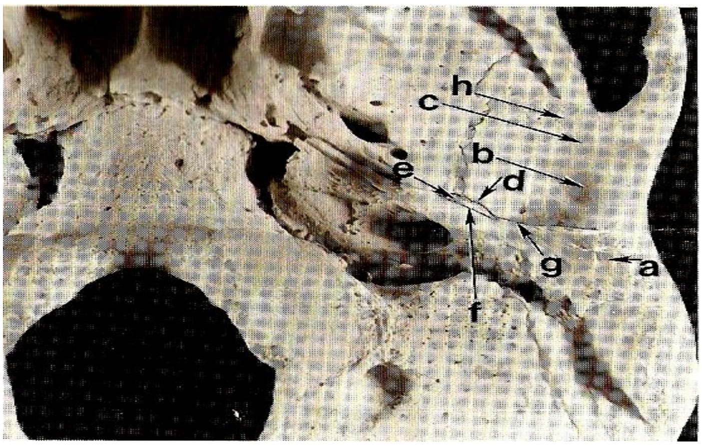



Figure1.9. Basal view of left side of human cranium(a)external auditory meatus, (b)glenoid fossa (c)articular eminence (d)petrosquamous fissure (e)tagmentympani (f)petrotympanic fissure (g)tympanosquamous fissure (h)preglenoid plane (**Hylander, 1992**).

In the back and lateral part of the glenoid fossa, a fissure separates the tympanic portion from the squamous portion of temporal bone. This fissure, which is called the tympanosquamosal fissure, separates the articular from nonarticular portion of the glenoid fossa (fig1.9). Medial to this fissure, a bony plate of petrous temporal, the tagmentympani, protrudes between the tympanic and squamous portions. Therefore, instead of a tympanosquamosal fissure along the medial aspect of the glenoid fossa, there is an anterior petrosquamosal fissure and posterior petrotympanic fissure. The petrotympanic fissure is slightly widened laterally to permit the passage of the chorda tympani nerve and the anterior tympanic blood vessel (**Hylander, 1992**).

The postglenoid tubercle also belongs to the squamous part of the temporal bone and forms the posterior border of the glenoid fossa. The fissure that separates the fossa from the tympanic portion of the temporal bone is called the petrotympanic fissure (squamotympanic fissure) **(Katzberg and Westesson, 1993)**.

## 1.7. TMJ and Occlusion

The influence of occlusion on joint morphology is still not completely understood, some investigators have failed to demonstrate correlation between occlusal factors and joint morphology **(Burley, 1961; Matsumoto andBolognese, 1994)**, whereas others indicated that occlusal factors are related to joint morphology **(Breitner, 1941; Matsumoto and Bolognese, 1995)**.

It is well known that the mandibular condyle is important for the development of the craniofacial skeleton and in particular for the growth of the mandible. The condylar process with its cartilaginous head is particularly vulnerable to genetic and environmental influences, which lead to various unilateral or bilateral disturbances in growth that in turn are reflected clinically as malformations of the entire lower two thirds of the face **(Berger and Stewart ,1977 ; Markey et al., 1980; Speculand, 1982; Subtelny,1985)**.

**Henderson and Poswillo (1985)** stated that "the condyles serve as an adjustable link between the tooth-bearing alveolar processes and the base of the skull". When condylar form or function is seriously disturbed, by congenital or acquired anomalous development, the effects on the whole mandible can be severe.

Structural and functional changes of the TMJ were found to be related to a characteristic facial morphology; however, no occlusal characteristics were significantly correlated with dysfunction. **(Stringert and Worm's, 1986)**

**Solberg et al., (1986)** in a cadaver study concluded that "malocclusion was associated with morphologic changes in the TMJ, particularly when combined with age". This evidence supports the belief that longer exposure to malocclusion may be associated with more extensive TMJ changes, and the findings could be related to ethnicity rather than pathology.

The observation that the condyle and temporal fossa have the potential to undergo significant change in shape during the period from early adolescence to adulthood may account for some of the variation in the joint-space measurements and measures of morphology **(Oberg et al., 1969; Solberg et al., 1985; Dibbets and Van der Weele, 1991).**

**Matsumoto and Bolognese (1994)** found no correlation between radiographic morphologic characteristics of the temporomandibular joint and occlusion in a group of class I malocclusion subjects. By evaluating human autopsy material, on the other hands, the observation of **Matsumoto and Bolognese (1995)**, whose study on dried skulls, demonstrated a significant correlation between the condyle and the depth of the mandibular fossa.

The condyles are the cornerstone of mandibular form and function. The growth and development of the jaws and occlusion depend to a large extent on the integrity and health of the mandibular condyles **(Dimitroulis, 1997)**.

Variations in craniofacial morphology, growth direction, and malocclusion have been shown by various authors to play a role in positional and morphological relationships of the temporomandibular joint **(Pullinger et al., 1987; and Burke et al., 1998).**

The observation that many subjects have "occlusal abnormality" without TMD has clearly encouraged reviewers to conclude that occlusal factors have no significant etiological role **(Clark, 1991; DeBoever et al., 2000)**. Results of experimental interference studies are also seen as a strong evidence for the same conclusion **(Tsukiyama et al., 2001)**.

Condylar movements are controlled not only by the shape of the articulating surfaces and the contraction patterns of the muscles but also by the dentition. The dentition also determines the end position as well as the movement of the condyle-disc complex **(Palla, 2004).**

## 1.8. Malocclusion

Malocclusion is a continuum ranging from ideal occlusion to considerable deviation from normal, and the severity of malocclusion is how far a malocclusion deviates from normal, which can be measured objectively using occlusal indices (**Koochek et al, 2001**)

Angle's (**Angle, 1899**) classification of malocclusion was an important step in the development of orthodontics. It had not only subdivided the major types of malocclusion, but also provided the first clear definition of normal occlusion in natural dentition. Then, numerous classifications have been developed but yet none has been universally accepted. This could be due to variations in the terminology, sampling differences of age and sex, levels of severity and the accuracy of examining methods **(Isaacson et al., 1977**).

Angle's classification is based on the antero-posterior relationship of the jaws with each other and does not take into account the vertical or transverse discrepancies which were studied later by **Cryer (1904), Case (1904), Hellman (1921), Simon (1926)** and **Ackerman and Proffit (1969)**.

Angle's classification has remained widely accepted and used in most dental schools and practices which considered it the most practical and popular method of studying occlusion and confirmed the simplicity and practicality of this system (**Graber and Swain, 1985; Moyers, 1988; Graber and Vanarsdall, 1994**).

### *1.8.1. Skeletal Relationship*

#### *1.8.1.1. <u>Antero-posterior (sagittal) Relationship</u>*

Antero-posterior skeletal malocclusions are commonly defined by the relationship of the maxilla and mandible to the cranium. Class III skeletal malocclusions are defined as the condition of occlusion in which the mandible is placed in a relatively protrusive position. The opposite Antero-posterior skeletal dysplasia is the class II malocclusion, which is defined as the condition in which the mandible is relatively retruded. This Antero-posterior imbalance can result from several possible theoretical relative differences: (**Droel and Isaacson, 1972**)

1. The mandible may be too large or too small relative to the maxilla. Growth occurred in the proper direction, but either too little or too much was present.

2. The mandible may have grown primarily in an anterior or primarily in a downward direction, resulting in a relatively too much or too little structure relative to the maxilla.

3. The maxilla also may be too small or too large, or it may be positioned in a retrusive or protrusive position relative to the mandible.

4. The mandible may be functionally positioned too far forward in pseudo-class III malocclusions, with the result that the mandibular condyles are out of the glenoid fossa.

5. The glenoid fossa may be positioned relatively too far anteriorly or posteriorly. This would result in an abnormal position of the mandible relative to the maxilla in spite of favorable amount and direction of growth when the condyles were properly positioned in the glenoid fossa.

The Antero-posterior positional relationship of the basal parts of the upper and the lower jaws to each other, with the teeth in occlusion is known as the sagittal skeletal relationship (**Foster, 1985; Houston and Tully, 1993**).

The Antero-posterior skeletal malocclusions are classified according to ANB angle **(Ballard 1948, Foster 1990,** and **Jones and Oliver 2000)** into:

❖ ***Skeletal class I:***

In which the jaws are in their normal Antero - posterior relationship in occlusion. Point **B** lies a few millimeters behind point **A**. **(2° ≤ ANB ≤ 4°)**

❖ ***Skeletal class II***:

In which the lower jaw in occlusion is positioned further back in relation to the upper jaw than in skeletal class I, or the maxilla gains more prognathism relative to the mandible. **(ANB > 4°)**

❖ ***Skeletal class III:***

The mandible is protruded relative to the maxilla, or the maxilla is retruded relative to the mandible**. (ANB < 2°).**

Variations in the skeletal relationship can be due to (Fig.1.10, 1.11)

a. Variation in size of the jaws.
b. Variation in the position of the jaws in relation to the cranial base, therefore if one jaw is smaller or larger than the other in the Antero-posterior dimension the development of class II or class III relationship may result (**McDonald and Avery, 1978; Mills, 1987; Bishara et al., 1994; Jacobson, 1995**).

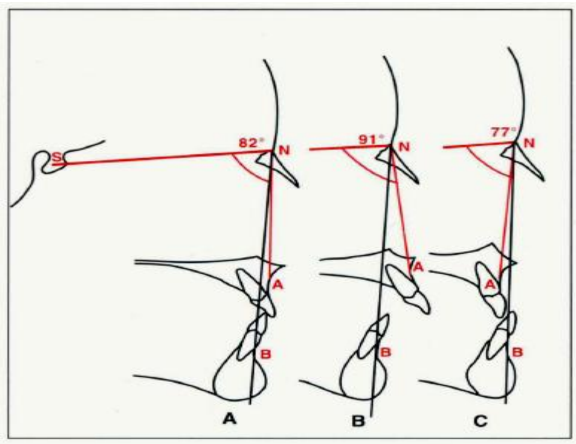



**Fig 1-10** SNA angle: A, SNA of 82 degrees is the mean reading for this angle; B, SNA angle of 91 degrees suggests a protrusive maxilla; C, SNA angle of 77 degrees suggests a recessive maxilla (**Jacobson, 1995**).

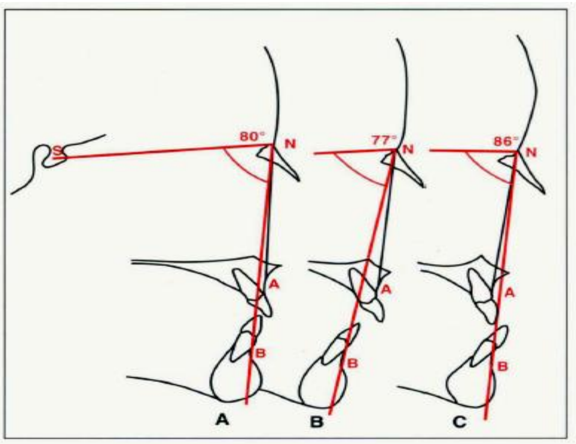



**Fig 1.11** SNB angle: A, SNB angle of 80 degrees is the mean reading for this angle; B, SNB angle of 77 degrees suggests a recessive mandible; C, SNB angle of 86 degrees suggests a protrusive mandible (**Jacobson, 1995**).

### *1.8.1.2. Vertical relationship*

Vertical skeletal malocclusions are commonly defined in terms of the height of the lower portion of the face relative to the total height (**Wylie and Johnson, 1952**)

The following vertical components can affect vertical facial dimensions **(Isaacson et al., 1971):**

1. The amount of vertical growth between sella-nasion and the palate, primarily sutural growth.
2. The amount of growth between the palate and occlusal plane, mainly the maxillary alveolar process.
3. The amount of growth between the occlusal plane and the lower border of the mandible, mainly the mandibular alveolar process.
4. The amount and direction of condylar growth of the mandible.
5. The vertical position of the glenoid fossae relative to the cranium.

The vertical skeletal malocclusions were classified according to **Schudy (1964)** on the basis of MP-SN angle into:

- ❖ Normal angle: when the MP-SN = 30º < MP-SN < 40º.
- ❖ Low angle : when the MP-SN < 30°.
- ❖ High angle : when the MP-SN > 40°.

Vertical skeletal relationship was classified according to **Droel and Isaacson (1972)** on the basis of MP-SN angle values into:

- ❖ Normal angle: when the MP-SN = 28° < MP-SN < 36.5°.
- ❖ Low angle : when the MP-SN < 28°.
- ❖ High angle : when the MP-SN > 36°.

## 1.9. Mandibular rotation

Since the mandible is suspended under the cranium, the mandibular displacement with growth will depend not only on the growth of the condyles, but also on the lowering of the maxillary complex and of the articular fossae relative to the anterior cranial base. Lowering of the maxillary complex will displace the anterior tooth-bearing part of the mandible, whereas condylar growth and lowering of the articular fossae will displace its posterior part **(Solow, 1980)**.

### *1.9.1. Forward Rotation*

When the condylar growth is greater than vertical growth in the molar area, the mandible rotates forward**.** With this type of rotation; less increase in anterior facial height and more horizontal change of the chin, nearly always accompanied by a forward movement of pogonion and an increase in the facial angle, flattening of the mandibular plane which tends to increase the vertical overbite and renders vertical overbite correction and retention more difficult, and extremes of this condition cause closed bites **(Schudy, 1965; Isaacson et al., 1977)**.

Each rotation has a center which is at the intersection of the perpendicular bisector of any two chords of concentric circles created by the rotation. One such chord could be represented by the vector of condylar growth. An ankylosed tooth, an implant, or internal mandibular structures (any structure that is not itself changed) produce chords. It is Antero-posteriorly located by the proportionality between vertical condylar growth and the sum of the vertical growth in the molar region. The center of rotation may be located at the posterior or anterior ends of the bone or somewhere in between. According to the location of the center of rotation; Bjork described the forward mandibular rotation in three ways as shown in Figure 1-12 **(Bjork, 1969)**:

**Type I:** In this type (the one that is usually considered) there is a forward rotation about centers in the joints which gives rise to a deep-bite, in which the lower dental arch is pressed into the upper, resulting in underdevelopment of the anterior face height. The cause may be occlusal imbalance due to loss of teeth or powerful muscular pressure. This lowering of the bite may occur at any age.

**Type II:** Forward growth rotation of the mandible about a center located at the incisal edges of the lower anterior teeth is due to the combination of marked development of the posterior face height and normal increase in the anterior height. The posterior part of the mandible then rotates away from the maxilla. The increase in the posterior face height has two components; the first is the lowering of the middle cranial fossae in relation to the anterior leading to bending of cranial base and lowering of the condylar fossae. The second component is the increase in the height of the ramus.

**Type III:** In anomalous occlusion of the anterior teeth, the forward rotation of the mandible with growth changes its character. In the case of large maxillary overjet or mandibular overjet, the center of rotation no longer lies at the incisors but is displaced backward in the dental arch, to the level of the premolars. In this type of rotation the anterior face height becomes underdeveloped when the posterior face height increases. The dental arches are pressed into each other and basal deep-bite develops.

In type II and III, the mandibular symphysis swings forward to a marked degree, and the chin becomes prominent.

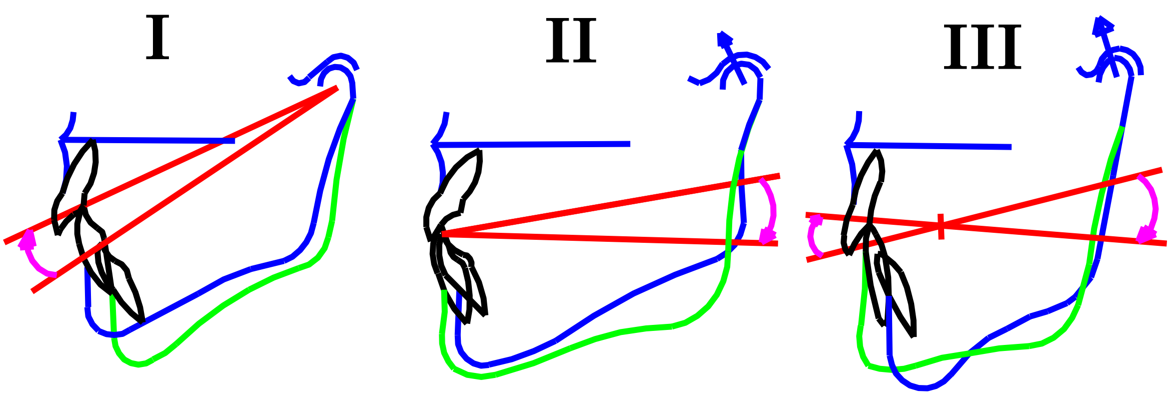



Figure1.12 types of forward mandibular rotation **(Bjork, 1969)**

### 1.9.2. *Backward Rotation*

When the vertical growth in the molar region is greater than that at the condyles, the mandible rotates backward resulting in more anterior facial height and less horizontal change of the chin, pogonion cannot keep pace with the forward growth of the upper face and the mandibular plane becomes steeper. This condition would not help to reduce the ANB angle, facilitates the correction and retention of vertical overbite, and extremes of this condition cause open bites **(Schudy, 1965)**.

Backward rotation of the mandible is less frequent than forward rotation. According to the location of the center of rotation, two types have been recognized as observed in Figure 1-13 **(Bjork, 1969)**.

**Type I:** Here the center of the backward rotation lies in the temporomandibular joints. This is the case when the bite is raised by orthodontic means, by a change in the intercuspation or by a bite-raising appliance, and results in an increase in the anterior face height. Backward rotation of the mandible about a center in the joints also occurs in connection with growth of the cranial base. In the case of flattening of the cranial base, the middle cranial fossae are raised in relation to the anterior one, and then the mandible is also raised. There may be other causes also, such as an incomplete development in height of the middle cranial fossae, as in oxycephaly. This underdevelopment of the posterior face height leads to a backward rotation of the mandible, with overdevelopment of the anterior face height and possibly open bite as a consequence. The mandible is, in principle, normal.

**Type II:** Backward rotation here occurs about a center situated at the most distal occluding molars. This occurs in connection with growth in the sagittal direction at the mandibular condyles. In the subjects analyzed so far, the direction of this sagittal growth has curved increasingly backward. As the mandible grows in the direction of its length it is carried forward more than it is lowered in the face, and because of its attachment to muscles and ligaments it is rotated backward. The symphysis is swung backward as well as the chin. This type has been found in various cases of condylar hypoplasia.

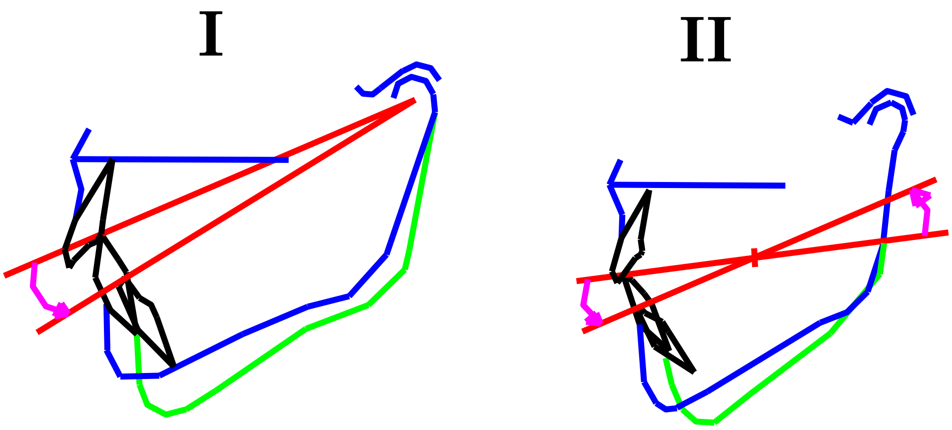



Figure1.13. Types of backward mandibular rotation with the center at the joint (I) and with the center at the last occluding molars (II) **(Bjork, 1969)**

**Björk and Skieller (1983)** stated that both forward and backward rotations of the mandible were divided into three components:

1. ***Total rotation*** is the rotation of the mandibular corpus and is measured as change in inclination of a reference line, or an implant line, in the mandibular corpus relative to the anterior cranial base. When the implant line or reference line rotates forward relative to the Nasion-Sella line during growth, the total rotation is designated as negative. When the mandibular implant or reference line rotates backwards relative to the Nasion-Sella line, total rotation is designated as positive.

2. ***Matrix rotation*** expresses a rotation of the soft tissue matrix of the mandible relative to anterior cranial base. The soft tissue matrix is defined by the tangential mandibular line **(Björk, 1947)**. The matrix rotation is recorded as negative when the tangential mandibular line rotates forward relative to the Nasion-Sella line. When the tangential mandibular line rotates backwards relative to the Nasion-Sella line, matrix rotation is designated as positive. The matrix sometimes rotates forwards and sometimes backwards in the same subject during the growth period, with the

condyles as the centre of rotation, and can be described as a pendulum movement.

***3.Intramatrix rotation,*** the difference between the total rotation and the matrix rotation, termed the intramatrix rotation, is an expression of the remodelling at the lower border of the mandible and is defined by the change in inclination of an implant or reference line in the mandibular corpus relative to the tangential mandibular line. Forward rotation of the corpus relative to the tangential line is recorded as negative. When the implant or reference line in the mandibular corpus rotates backwards relative to the tangential mandibular line, intramatrix rotation is designated as positive.

### *1.9.3. Signs of Mandibular rotation (Al-Mulla, 2009)*

| | **Forward rotation** | **Backward rotation** |
|---|---|---|
| **1** | **Wide and long ramus.** | **Narrow and short ramus.** |
| ***2*** | **Upward forward direction of condylar growth.** | **Upward backward direction of condylar growth.** |
| **3** | **Mandibular angle more acute and canal more curved.** | **Mandibular angle obtuse and canal is linear.** |
| **4** | **Posterior alveolar process not well developed in vertical direction.** | **Posterior alveolar process well developed in vertical direction.** |
| **5** | **T.M.J caudally positioned.** | **T.M.J cranially positioned.** |
| **6** | **Decreased anterior facial height.** | **Increased anterior facial height.** |
| **7** | **Thick and wide symphesis and prominent polonium.** | **Symphesis region elongated with small depth.** |
| **8** | **Mandibular lower border is convex.** | **Mandibular lower border is concave** |
| **9** | **Center of rotation in the incisors or premolar region.** | **Center of rotation in the condyles.** |

## 1.10. Differential Loading within the TMJ

The stress bearing portion of the TMJ is located along the articular surfaces of the articular eminence of the temporal bone and the mandibular condyle. There is considerable evidence however, that reaction forces within this articular region are not always equally distributed. The evidence for differential loading within the human TMJ initially came from a study on patterns of remodeling and on pathological changes. **Moffett et al** (**1964**) showed that the lateral aspect of the human TMJ remodels differently from the medial aspect.

**Oberg et al** (**1971**) studied degenerative changes in human TMJ and noted that the majority of articular disc perforations are found along the lateral aspect of the TMJ. As pathological changes in joints are often related to local mechanical factors, these data indicate that the lateral aspect of the TMJ experiences more stress (more wear and tear) than medial aspect. The distribution of glycosaminglycans in articular tissues of human TMJ also indicates that the lateral aspect of the joint may experience more stress than the medial aspect (**Kopp, 1976; 1978**).

There are at least three possible reasons why the lateral aspect of the TMJ experiences more chewing stress than its medial aspect. One is related to mandibular distortions that occur due to powerful muscles and reaction forces (**Hylander, 1979**). The mandibular corpus of primates is twisted during the power stroke of mastication and during isometric biting. This twisting, which results in eversion of the lower border of the mandible and inversion of the coronoid process, causes the lateral part of the mandiblar condyle to be pressed more vigorously against the articular eminence than its medial part(Fig.1.13A). This presumably can occur on both the ipsilateral and contralateral condyles.

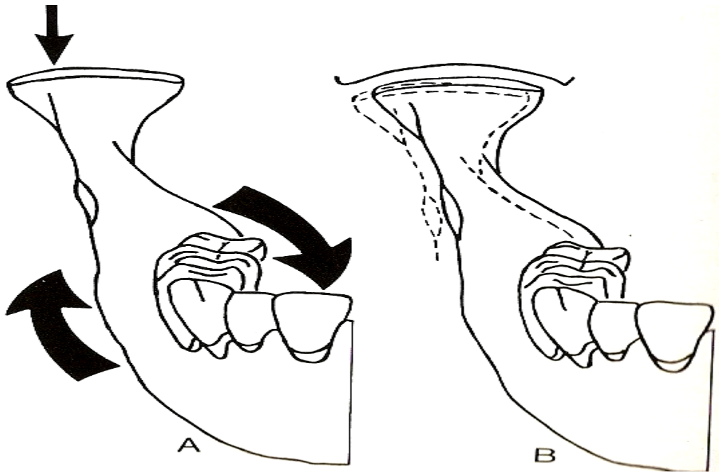



Figure 1.14 Differential loading of TMJ.A, the mandibular corpus during mastication and biting is twisted about its long axis(large arrow indicates the direction of twisting of the posterior half of the mandible ).This pattern of twisting causes the lateral aspect of the TMJ(small arrow) to be loaded more than its medial aspect. B, the mandibular condyle and posterior slope of the articular eminence along the epsilateral side during mastication. The epsilateral condyle is shifted laterally (dashed lines) during the opening stroke of mastication (**Hylander, 1992**)

The second reason for increased loading of the lateral aspect of the TMJ is advanced by **Mohl** (**1988**), who suggested that because the lateral pole of the condyle lies in front of the transverse axis of rotation of the mandible and the medial pole lies behind this axis, the lateral pole moves upward while the medial pole moves downward during the power stroke of mastication. These movements are thought to cause the lateral aspect of the mandibular condyle to press against the articular eminence while the medial aspect of the condyle loses contact with the eminence.

The third reason for differential loading within the TMJ is related to the mediolateral translation of the condyle relative to the articular eminence during unilateral mastication. The epsilateral condyle experiences a lateral shift (Bennett's movement) during the opening stroke of mastication. This is followed by a medial shift of the same condyle from this lateral position during the closing and power strokes. The medial shift is not only correlated to the occurance of maximum masticatory force (and therefore maximum condylar reaction force), but also related to epsilateral condyle positioned more laterally relative to the articular eminence. This is the most lateral portion of the articular eminence (Fig 1.14b), while at this time contact is reduced or lost between the medial half of the condyle, disc, and articular eminence.

Thus, throughout the early part of power stroke, and on into Phase I movement, the lateral aspect of the epsilateral TMJ may experience more stress than its medial aspect due to the position of the condyle and disc relative to articular eminence. When centric occlusion reached, the stress bearing portion of the condyle and eminence will no longer have a steep medial- to- lateral gradient of increasing joint reaction force. Instead, the TMJ reaction force more evenly distributed along the condyle, disc, eminence. Phase II movement probably does not result in significant differential load within TMJ simply because masticatory forces, and therefore condylar reaction forces, have declined considerably at this time.

Although the contralateral TMJ may frequently experience more overall stress than the epsilateral TMJ during powerful chewing, presumably its articular surfaces are more evenly loaded because the contralateral condyle does not experience a mediolateral type of movement that modifies the position of the articular components thereby causes large stress concentrations. Instead the contralateral condyle primarily rotates about a transverse axis and translates posteriorly down the articular eminence during the power stroke (**Hylander, 1992**)

**O'Ryan and Epker** (**1984**) have demonstrated different loading characteristics of the TMJ associated with different skeletal patterns. Through examination of the trabecular patterns of condyles from Class I, Class II open bite, and Class II deep bite skeletal patterns, they deduced the vectors of condylar loading in the functioning joint. They found that the functional loading patterns in these cases were significantly different. The external and internal morphology of a given bone or joint in an adult is determined by the biomechanical loads placed upon it during growth (**Hylander; 1985; Hylander and Johnson 1997**).

In skeletal Class III cases, they found that patients with different malocclusions or dentofacial deformities often have different TMJ morphologies

(**Ueki et al., 2000**). Furthermore, they found that mechanical stress on the TMJ also varied with the individual TMJ morphology (**Ueki et al., 2005**). These loads arise from the functioning of the associated musculature**.** The differences in skeletal pattern induce differences in stress distribution on the TMJ; the anatomical morphology of TMJ was also associated with stress direction and distribution on the condyle. (**Ueki et al., 2008**)

## 1.11. Remodeling of temporomandibular joint

**Moffett (1966)** defined articular remodeling as the morphological adaptation of joints in response to biomechanical stress. The bones and articulations of the craniofacial skeleton grow and function in an environment of mechanical forces. These forces which include muscle activity, mastication, the expansile growth of the brain, gravity, and man-made orthodontic appliancesinfluence the shape and relative position of each bone in the complex, through the process of biological adaptation termed 'remodeling' (Fig1.15) (**Moffett, 1971, 1973**).

In a study of articular remodeling in human synovial joints, **Johnson** (**1959**) concluded that progressive remodeling added 3 mm of new bone to the femoral head between the ages of 30 and 60 yrs. The remodeling of articular cartilage is a process of biological adaptation to changing environmental circumstances.

Joint growth stops at about 18-20 years of age (earlier in men than in women).After that time soft and hard tissues undergo continuous change (they are continuously remodeled). Articular remodeling is considered as normal adaptation of soft and hard tissues to the load changes within the joint. Joint remodeling leads to changes in the shape of the condyle and fossa which may disturb normal joint biomechanics. This form change may cause a high degree of incongruence between condyle and fossa so that the disc tissue may undergo greater stress concentration (**Palla, 2004).**

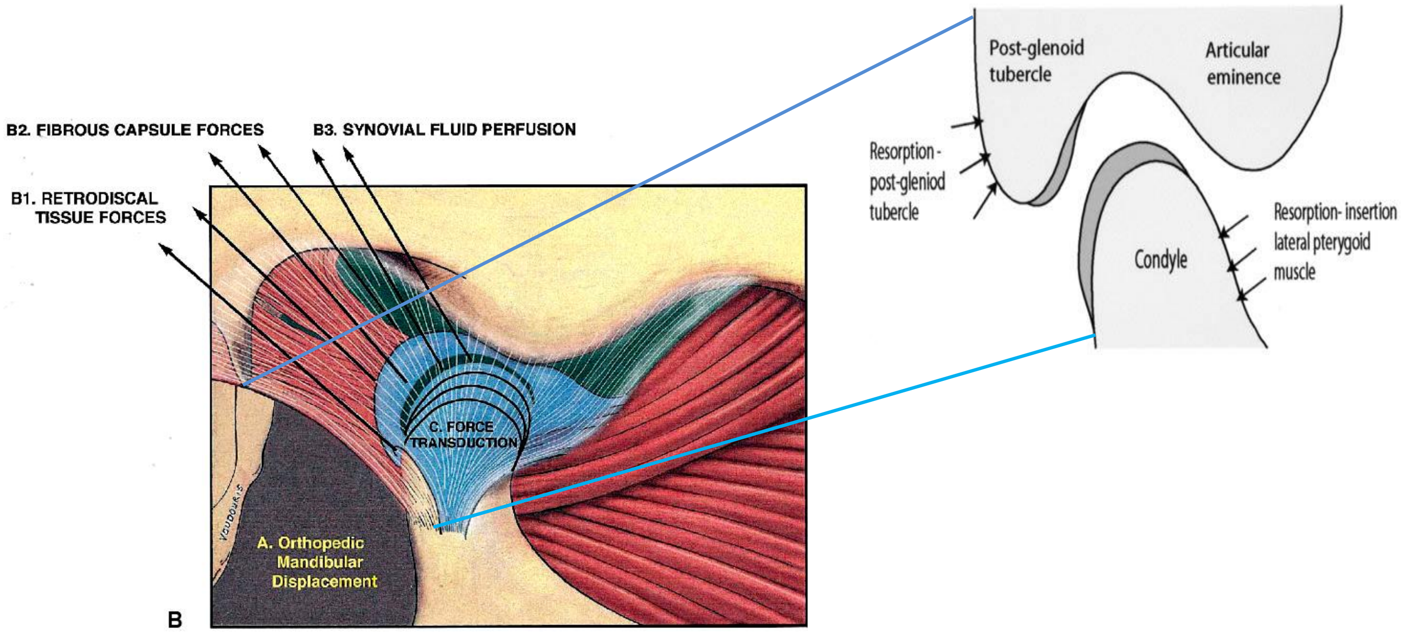



Figure1.15 A. orthodontic displacement, B viscoelastic tissue pull (arrows, B1, B2, B3), C. Force transduction. The forces are translated to the condyle with the articular disk (*blue region*) posterior, anterior, lateral and medial (collateral) attachments **(Voudouris and Kuftinec, 2000).**

### *1.11.1. Classification of Articular Remodeling*

Articular remodeling in the human synovial joints was classified by **Johnson (1959)** into three categories: progressive, regressive and peripheral or circumferential. Progressive remodeling results from a proliferation of articular cartilage followed by its mineralization and eventual osteogenic replacement. Regressive remodeling results from osteoclastic resorption of the subchondral bone with subsequent filling of the cavities by mesenchymal tissue and its replacement by cartilage, bone, or both. Peripheral remodeling occurs at the margin of the articular cartilage and is a combination of progressive remodeling and periosteal deposition **(Meikle, 1992)**

### *1.11.2. Changes in the Temporomandibular joint*

The morphological changes associated with articular remodeling in the human TMJ were studied by **Moffett** (**1964**) and **Blackwood** (**1959; 1966**). They identified all three types of remodeling actively described by **Johnson** (**1959**) and showed the following distribution trends: progressive remodeling on the anterior part of the condyle, medial part of the articular eminence, and the roof of glenoid fossa; regressive remodeling on the posterior part of the condyle and lateral part of the articular eminence; and peripheral remodeling mainly at the anterior articular margin of the condyle **(Meikle, 1992)**.

### *1.11.2.1. Progressive Remodeling*

The earliest changes that can be observed histologically both at the condyle and the articular eminence are hypertrophy of the cells of the proliferative zone accompanied by increased production of extracellular matrix. This newly formed cartilaginous tissue becomes mineralized and eventually resorbed and replaced by bone, although some islands of mineralized cartilage matrix may remain un-resorbed. These changes take place without any apparent alteration in the structure of the articular zone **(Meikle, 1992)**. Progressive remodeling is characterized by tissue proliferation, i.e. by an increase in the volume of the remodeled tissue with higher cell density and/or higher number of cells of a certain phenotype **(Palla, 2004)**.

### *1.11.2.2. Regressive Remodeling*

The first observable change is resorption of the subarticular bone and adjacent cartilage by osteoclast. Initially, the resorption cavity is filled by vascular mesenchymal tissue, but eventually this is replaced by fibrocartilage, bone or both. Although the tissue of articular zone remains intact, the net effect of regressive remodeling is to reduce vertical dimension of the underlying bone **(Meikle, 1992).** In regressive remodeling there is a decrease in tissue volume and in cell number as well as other signs of tissue degeneration **(Palla, 2004)**.

### *1.11.2.3. Peripheral Remodeling*

The characteristic feature of peripheral remodeling is that the cellular activity originates from the proliferative zone. This gives rise to an outgrowth of cartilage at the anterior border of the condyle immediately above the insertion of lateral pterygoid muscle. This cartilaginous outgrowth eventually becomes mineralized and replaced by bone to produce an osteophytic lipping of the articular contour **(Meikle, 1992)**.

### *1.11.3. Clinical implication of TMJ Remodeling*

**Paulsen (1997)** studied 100 consecutive patients treated with the Herbst appliance. **Paulsen** reported that, in most cases, a visible change in the morphology of the condyle occurred, a double contour of the postero-superior part of the condyle, and sometimes at the distal surface of the ramus. In children/youth at the peak of puberty, the double contour was distinct only for a short time, while in late puberty it persisted for several months. Paulsen concluded that the observed changes were due to bone remodeling.

**Ruf and Pancherz (1998)** used magnetic resonance imaging (MRI) to analyze TMJ growth adaptation in 15 consecutive Class II patients treated for a period of 7 months. After 6-12 weeks, signs of condylar remodeling were seen at the postero-superior border in 29 of the 30 condyles, while glenoid fossa remodeling was noted in 22 joints.

**Ruf and Pancherz (1999)** assessed the function of the temporomandibular joint anamnestically, clinically, and by means of magnetic resonance images (MRIs) taken before, after, and 1 year after herbst treatment. The condylar position was assessed metrically on the parasagittal MRIs in the closed mouth position. It had been found that a considerable variation in condyle position is found in the sample both before and 1 year after herbst treatment.

**Popowich et al. (2003)** studied class II patients treated with herbst appliances. Magnetic resonance imaging, computerized tomography scans, or tomography (axially or horizontally corrected) had been used to image the TMJ. The effect of herbst appliance theory on TMJ morphology can be summarized as changes in condyle position relative to the glenoid fossa are minor and not clinically significant. The nature of condyle and glenoid fossa remodeling and disc position changes had not been established.

**Katsavris and Voudouris (2003)** undertook a study to determine the contribution of glenoid fossa modification in the correction of skeletal class II malocclusion, individually corrected lateral tomograms of 35 patients were taken on pre- and post treatment basis and the conclusion from this study was that; the glenoid fossa did not show changes in morphology radiographically as a result of treatment with mandibular protrusive appliances (activators) and contrarily to the common belief, the glenoid fossa did not appear radiographically to contribute growth modifications to the class II correction by active bone remodeling.

**Hatice and Golkman (2004)** conducted a study on lateral cephalograms and magnetic reasonace images obtained from 20 subjects mean age was 8.9 year s with cl.III malocclusion, only clinically temporomandibular joint symptoms free subjects were included in this study. Condyle position relative to glenoid fossa was determined by the equation which was used by **Pullinger et al (1985)**. This study showed that the application of chin cap created morphologic changes in the temporomandibular area and that these changes stimulate the remodeling of the mandible. For this reason, improvement of skeletal cl.III malocclusion can be understood of a combination of both morphologic changes of the TMJ and remodeling of the mandible.

Remodeling of the TMJ with the Herbst appliance (and probably the twin-block) can be regarded as a definite clinical possibility, particularly in an actively growing child (**Meikle, 2007)**.

## 1.12. Cephalometic radiography

### *1.12.1.Definition:*

It is scientific measurement of the dimensions of the head. It is the first to prove of value in orthodontics and it was used to assess craniofacial growth and to determine treatment responses **(Rakosi, 1982)**.

### 1.12.2. History:

The first X-ray pictures of the skull in the standard view were taken by **Pacini (1922)**. In subsequent years, the following authors also produced this type of radiograph for the evaluation of craniofacial measurements **McCowen (1923)**, **Simpson (1923)**, **Riesner (1929)**, and others. None of them gave an accurate description of the methods used to take the pictures and for their evaluation, so that one can only speak of individual studies. **Hofrath (1931)** developed a standardized method for the production of cephalometric radiographs, using special holders known as cephalostats, to permit assessment of growth and treatment response.

### 1.12.3. Types of Cephalometric Radiographic Views:

According to **Graber and Vanarsdall (1994)**, the commonly used radiographic views are:

1. Lateral or profile cephalograms: which are used to study antero-posterior and vertical relationships.
2. Frontal or postero-anterior cephalograms: which are used to evaluate the transversal and vertical relationships in the frontal plane.
3. Submental vertex or basal cephalograms: are used to examine the balance in transversal plane.

## 1.13. Computerized Radiography

### 1.13.1. Panoramic Projection

Because the panoramic projection provides an overall view of the teeth and the jaws, it serves as a screening projection to identify odontogenic diseases and other disorders that may be the source of TMJ symptoms. Gross osseous changes in the condyles may be identified, such as asymmetries, extensive erosions, large osteophytes, or fractures (Fig 1.16) **(White and Pharoah, 2004)**.

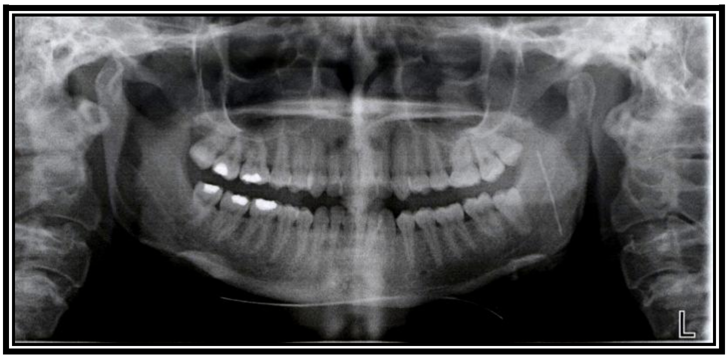


Fig 1.16 Panoramic Projections *(White and Pharoah, 2004)*

### *1.13.2. Cephalometric Projection*

**Barrett et al. (1968)** was the first to suggest the use of digitizer or a similar machine in the measurements of cephalometric radiographs. Several authors have concluded that computer analyses are unlikely to introduce more measurement error than hand tracing, as long as landmarks are identified manually **(Baumrind and Frantz, 1971; Gravely and Benzies, 1974)**.

The comparison of manual tracing with a direct method using a digitizing tablet revealed that direct digitization is more reproducible. The reproducibility of "on screen" computer digitization, in which the cephalograms were imaged onto the computer screen via a video camera, was comparable with manual tracing method **(Jackson et al., 1985)**.

**Harris and Reynolds (1991)** demonstrated the advantages of computerized cephalometrics:

- Angles and distances can be traced, calculated or listed together with mean values for comparisons.
- Any number of copies of computerized tracing can be produced.
- One can obtain a series of superimposition of computerized tracing before and after therapy registered on different structures, such as SN line at S, or SN at N.
- The population "norm" template tracing can be superimposed on patient tracing.

- A prognosis tracing can be generated to demonstrate the effect of possible procedures.
- Stored data can be retrieved for clinical or research purposes.

**Oliver** (**1991)**, found that conventional digitizing, on-screen digitizing and manual tracing were all comparable in accuracy. On screen digitizing has advantages in particular regarding the time taken to enter data, ability to enhance and enlarge portions of the image, and the ease in producing analyses. However, hand tracing is still anticipated to be popular, as it is still less costly and more easily accessible.

Digitizing can introduce additional errors such as head film movement and improper sequencing of points. However, with proper technique, the only significant source of error is landmark identification **(Richardson, 1981; Konchak and Koehler, 1985; Baskin and Cisneros, 1997)**.

## 1.14. *Cephalometric analysis*

It is a diagnostic tool used to determine the type and focus of therapy for an individual patient **(McNamara, 1984)**. Cephalometric analysis is used to determine the relationship of dento-facial complex. Cephalogram can also help the orthodontist to determine the changes that are associated with growth and/ or orthodontic treatment. **(Bishara and Feruson, 1985)**

The process of evaluating skeletal, dental and soft tissue relationships of patients is done by comparing measurements performed on the patient's cephalometric tracing with population norms for the respective measurements, so as to come to a diagnosis of the patient's orthodontic problem **(Daskalogiannakis, 2000).**

Cephalometric analysis is one of the several diagnostic aids. Orthodontic diagnosis cannot be made solely on the basis of cephalometric analysis. It is a valuable aid in diagnosis only if their findings are correctly and wisely interpreted with the help of other diagnostic aids **(Bishara, 2001)**.

### *1.14.1.Methods of cephalometric radioghraphic analysis:*

**Salzmann (1966)** stated that Camper was probably the first to employ angles in measuring the face via his triangle (Camper triangle). More recently, varying techniques of diagnostic analysis have been introduced. **Brown (1981)** estimated about fifty different methods of analysis, while **Rakosi (1982)** brought to the attention that there were over a hundred types of cephalometric analyses. The most important analyses include:

- **Bjork's analysis (1947)**
- **Steiner's Analysis (1953).**
- **Ricketts' analysis (1961, 1981).**
- **McNamara Analysis (1984).**
- **Bimler's analysis (1985).**

## 1.15. Advantages of Digital over Conventional radiography

- ***Dose reduction:*** Dose reductions of up to 90 percent compared to E-speed film have been reported by some authors in the diagnosis of caries **(Wenzel et al., 1995)**
- **Image manipulation:** This is the greatest advantage of digital imaging over conventional films. It involves selecting the information of greatest diagnostic value and suppressing the rest. Manufacturers provide software programmes with many different processing tools, however some are more useful than others and these include: **(Brennan, 2002)**

1. ***Contrast enhancement:*** This can effectively compensate for over or under exposure of the digital image. It has been shown that contrast enhancement of Charge Couple Device (CCD) was more accurate

than E-speed film for detecting simulated caries under orthodontic bands **(Reichl et al., 1996)**.

2. ***Measurements:*** Digital calipers, rulers and protractors are some of the many tools available for image analysis, and many authors have reported their application in cephalometric analysis. The images can also be superimposed onto each other and onto digital photographs. **(Gotfredsen etal. 1991; Lim and Foong, 1997)**

3. ***Filtration:*** The addition of filters to the airspace around the face can clarify the soft tissue profile if the original soft tissue image was poor **(Brennan, 2002)**

- ***Reduce wasting time:*** Much time is gained especially with the CCD system where the image is displayed at the chairside computer immediately post exposure. Although a lag time between scanning and the appearance of an image exists with the semidirect image plate system method, it is still substantially faster than conventional developing processes in general use **(Brennan, 2002)**

- ***Reduce the effect on environment:*** No processing chemicals are used or disposed for both CCD sensors and the semidirect image plate system which are capable of being reused for many thousands of exposures. They can, however, become scratched and damaged if not handled carefully **(Brennan, 2002)**

## 1.16. Reliability of Lateral Cephalometric Radiography

In contemporary orthodontics, lateral cephalograms are used for the assessment of treatment changes induced by the appliances used. Therefore, it is important to keep the method error to a minimum in order to see the valid small changes achieved by treatment **(Kamoen et al., 2001)**.

In cephalometry there are numerous sources of error. These errors may be classified into two categories: "projection errors" and "tracing errors". Projection errors occur in the conversion of a three dimensional object into a two dimensional radiograph; they vary with the relative positions of the X-ray tube, the object and the film. Tracing errors may be caused by lack of clarity of cephalometric landmarks due to superimposition of structures, blurring of the image brought about by movement during exposure, lack of film contrast and emulsion grain **(Gravely and Benzies, 1974)**. Tracing on paper using hand instruments is reported to compare favorably with the results of digitized radiographs and the findings of studies using manual methods could be considered perfectly valid **(Richardson, 1981; Sandler, 1988)**. Manual tracing was found to yield more reproducible results especially for the points Articulare and Gonion which are constructed on a tracing, but only estimated using the digitizer **(Sandler, 1988)**.

Other points were easier to visualize and locate when the outline of the structure could be traced first, such as the apex of the maxillary incisor root **(Houston, 1983)**.

Measurement errors associated with the thickness of the pencil line and the perceptive limits of the human eye also contribute to tracing errors **(Gravely and Benzies, 1974)**. Hand measurements are time-consuming and there is a risk of misreading the measuring instruments and registering data to the computer **(Sandler, 1988)**.

If digitization is carried out, then the angles and distances are automatically calculated which can eliminate the errors in drawing lines between landmarks and in measurements with a protractor. Moreover, the digital image can be manipulated to process the image and alter its visual appearance which can facilitate landmark identification **(Jackson et al., 1985)**.

**Savara and Takeuchi (1979)** reported that errors may be caused by variation of tissue images on consecutive cephalograms resulting from changes in relative positions of bony landmarks during child growth, unclear definition of anatomical landmarks, and insufficient training of landmark locators. When more than one locator designates landmarks on the same cephalograms, a lack of training or understanding of anatomical landmarks can result in inter-locator discrepancies. **Broadway et al. (1962)** and **Odeh (1985)** reported that inter-tracer error is generally higher than intra-tracer error.

Many investigators have shown that inconsistency in identification of cephalometric landmarks is an important source of error in cephalometry **(Hixon, 1956; Miller et al., 1966; Baumrind and Frantz, 1971)**. Some of the landmarks, used clinically, are located on the outlines of the cranium and are comparatively easy to identify due to the sharpness in contrast of the roentgenograms. The structures of the inner cranium are, on the other hand, often indistinct because of summations of superimposed anatomical details **(Midtgård et al., 1974)**.

## 1.17. TMJ Radiographical studies

**Ricketts (1953 and 1955)**, using laminography of the TMJ, had found that the condyle was well centered in the fossa and the articular surfaces were smooth in individuals with no significant joint disorders. He measured the average distance between the condylar anterior surface and the posterior slope of the articular eminence and found it to be 1.5mm. The condyle was located 7.5mm anterior to the center of the external auditory meatus and 2.5mm from the top of the condyle to the floor of the fossa. He found that variation from this position was possible in symptoms-free individuals. The condyle may be positioned either deep in the fossa or rather forward or downward. He stated that functional adaptation plays an important role in this variation. In his opinion, improper occlusion causes true distal displacement of the condyle and is associated with symptoms. Ricketts also suggested that the proper treatment could be provided by harmonizing the dental occlusion with joint structure and muscles.

**Baccetti et al. (1997)** conducted a retrospective study to determine the Glenoid fossa position in different facial types depending on true lateral cephalometric X-rays of 180 (90 males and 90 females) subjects, their age range of 7 to 12 years, classified into two groups according to sagittal and vertical skeletal relationships. It had been found that the position of glenoid fossa in CL.II subjects was more posterior than CL.III subjects, and the position of glenoid fossa in high angle subjects was more cranial than low angle subjects. The variables and readings of Baccetti et al are shown in Table 1.1.

**Table 1.1.** Mean values and standard deviation of Baccetti et al study in different sagittal and vertical skeletal patterns.

| Author (s) | | Baccetti *et al.* | Author (s) | | Baccetti *et al.* |
|---|---|---|---|---|---|
| Year | | 1997 | Year | | 1997 |
| Sample size | | 180 | Sample size | | 180 |
| Age | | 7-12 yr | Age | | 7-12 yr |
| Country | | Italy | Country | | Italy |
| Variables | Sagittal relation | Mean ± S.D. | Variables | Vertical relation | Mean ± S.D. |
| ANB° | Class I | 3.11±0.59 | MP-SN° | Normal | 35.32±1.31 |
| | Class II | 6.52±1.35 | | High | 44.65±2.79 |
| | Class III | -0.69±1.95 | | Low | 25.88±2.38 |
| T-FS' (mm) | Class I | 18.1±3.3 | T-FS' (mm) | Normal | 18.4±3 |
| | Class II | 18.9±2.6 | | High | 17.9±3.4 |
| | Class III | 17.5±3.3 | | Low | 17.8±2.9 |
| T-Ar' (mm) | Class I | 20.2±4.2 | T-Ar' (mm) | Normal | 20.3±3 |
| | Class II | 20.8±2.8 | | High | 20.2±4.2 |
| | Class III | 19.4±3.2 | | Low | 19.8±3 |
| FS-FS' (mm) | Class I | 19.8±3.8 | FS-FS' (mm) | Normal | 19.8±3 |
| | Class II | 20.3±2.8 | | High | 18.8±3.2 |
| | Class III | 20.1±3.2 | | Low | 21.6±3 |
| Ar-Ar' (mm) | Class I | 29±3.8 | Ar-Ar' (mm) | Normal | 28.9±3.2 |
| | Class II | 29.4±2.8 | | High | 28.1±3.4 |
| | Class III | 28.6±3.5 | | Low | 30±3.3 |
| Me-SBL (mm) | Class I | 101.7±8.4 | Me-SBL (mm) | Normal | 101.4±5.8 |
| | Class II | 102.2±7.2 | | High | 106.9±7.3 |
| | Class III | 101.4±7.4 | | Low | 97±6.5 |
| Go-SBL (mm) | Class I | 70.9±6.3 | Go-SBL (mm) | Normal | 69.8±4.5 |
| | Class II | 70±4.9 | | High | 67.1±4.9 |
| | Class III | 68.5±5.5 | | Low | 72.5±6.1 |

**Burke et al., (1998)** conducted a retrospective study to determine the correlation between condylar characteristics, depending on pre orthodontic axially corrected lateral tomograms of the left and right temporomandibular joints of 136 preadolescent patients, their age range of 10 to 12.5 years for males and 9 to 11.5 years for females. The condyle fossa measurements included: anterior, superior and posterior joint spaces, condyle head and posterior condylar ramus inclination, condyle neck width, and condylar shape and condylar surface area. It had been found that patients with vertical facial morphologic characteristics displayed decreased superior joint space and posteriorly angled condyles. Increased superior joint space and anteriorly angled condyles were significantly correlated to patients with a horizontal facial morphology. No significant correlations between the other condylar characteristics and facial morphology were determined.

**Al-Saffar (2004)** examined the position of the mandibular condyles by using clinical examination, laboratory investigation, and cephalogram which were employed on 41 selected patients who were orthodontically pretreated with class I and class II malrelationships with an age ranged between 10-14 years old. This study introduced a new variable which is condylar position record which represented condylar position and had relation to centric occlusion-centric relation variable, and articular angle which determined the position of the condyles and the glenoid fossa.

**Elias and Demetrios (2005)** studied the shapes of the condyle and the glenoid fossa in patients with class II and class III malocclusion. Axially corrected tomograms were used and it had been found that condyles were positioned more posteriorly in the class II group. The class III group had an intermediate anteroposterior position, but the condyle was closer to the fossa in the vertical direction.

**Rabban (2006)** studied the relationships of condyle to glenoid fossa in different skeletal patterns. Tomographic imaging technique was applied to obtain 252 (right & left) temporomandibular joint views. It had been found that the dominant condyle position in class I skeletal jaw relation was concentric, in class II was anterior and in class III was posterior, while in the vertical skeletal variation (anterior rotation) the dominant condyle positions were anterior and concentric, while no statistically significant difference in the posterior and no rotation groups, no certain condyle positions were observed at the same level. In general, there was a relation between gender (male & female) and side (left) of the entire sample and condyle position, while there was no relation in the right side of the whole sample. Finally, there was no specific spatial relationship of the condyle to fossa in asymptomatic subjects.

**Giuntini et al., (2008)** assessed the position of the glenoid fossa in subjects with Class II malocclusion associated with mandibular retrusion and normal mandibular size in the mixed dentition. They used lateral cephalometric projection and found that Subjects with Class II malocclusion presented with a significantly more distal position of the glenoid fossa, when compared with the control group.

**Innocenti et al.,** (**2009**) investigated the position of the glenoid fossa in subjects with Class III malocclusion associated with mandibular protrusion. They used lateral cephalometric projection and found that Subjects with Class III malocclusion had a significantly more mesial position of the glenoid fossa, when compared with the control group.

# CHAPTER TWO

# 2. Materials and Methods

## 2.1. Material

### *2.1.1. The sample*

The sample was selected partly from a group of patients who were attending the Orthodontic Department at College of Dentistry, Baghdad University, and another part was selected from under and postgraduate students at the same college with an age ranged between 18-30 years. Out of 176 Iraqi subjects clinically examined, only 124 subjects (44 males and 80 females) fulfilled the criteria of sample selection. Those subjects were clinically examined and radiographed and their lateral radiographs were analyzed to obtain the ANB and MP-SN angles to divide the sample into three sagittal skeletal classes and three vertical skeletal groups as following:

According to ANB angle, the sample was classified into three sagittal skeletal classes:

| Classes | Subjects number |
|---|---|
| Class I = 2° ≤ ANB ≤4° | 48 |
| Class II = ANB > 4˚ | 41 |
| Class III = ANB < 2˚ | 35 |
| Total | 124 |

The same sample was classified according to MP-SN angle into three vertical skeletal groups:

| Groups | Subjects number |
|---|---|
| Normal angle= 30˚ ≤ MP-SN ≤ 40˚ | 67 |
| High angle = MP-SN > 40˚ | 23 |
| Low angle = MP-SN < 30˚ | 34 |
| Total | 124 |

#### 2.1.1.1. The criteria of sample selection

1. All subjects are free from TMJ problems (Clinical and OPG Examinations).
2. No missing teeth (regardless the wisdom teeth).
3. No history of orthodontic treatment.
4. No history of facial trauma or surgery.
5. No history of rheumatoid arthritis and osteoid arthritis.

### 2.1.2. The Instruments (Figure 2.1)

1. Diagnostic set (mirrors, probes, and tweezers).
2. Kidney dish.
3. Cotton.
4. Sterilizer (Memmert, Germany).
5. Disposable gloves.
6. Two disinfectant agents (Alcohol and Spirit 75%)
7. Millimeter graded vernier (Dentaurum, Order- No. 042-751-00).


**Figure 2.1. The instruments of this study.**

### 2.1.3. *The Equipments*

#### 2.1.3.1. *Digital X-Ray units (Figure 2.2)*

The Planmeca ProMax X-ray unit uses panoramic and cephalometric techniques to produce X-ray images for the diagnosis of dentomaxillofacial anatomy. The Planmeca ProMax Dimax3 (available in the College of Dentistry/Baghdad University) includes a set of programs which provides a selection of exposure formats for all types of patients and diagnostic purposes **(User's Manual, 2004).**

Figure 2.2. Planmeca ProMax X-ray unit

#### 2.1.3.2. *Analyzing Tools*

1. Pentium IV portable computer (HP Pavilion dv 6500).
2. Analyzing software (AutoCAD 2008, Autodesk, Inc. version 23.1.51.0)
3. Mass storage device 2GB (Genix 2008).

## 2.2. The Method

### 2.2.1. *History*

General informations like name, age, and sex were recorded in a special case sheet **(See Appendix I).**

- ***Medical history;*** including past medical history, present illness, drug taken, hospitalization and family history to exclude any possible infective disease

(Hepatitis B, tuberculosis and …etc), debilitating disease, or arthritis that could affect the T.M.J.

- ***Dental history;*** including information about history of facial trauma, previous orthodontic treatment, TMJ problems, previously extracted teeth.
- ***Inspection;*** patient inspection is very important to determine if there is any facial asymmetry, orofacial syndromes, hypertrophy in one side of the face and facial trauma.

### *2.2.2. Clinical examination*

It was important that the patient be in natural head position with the lips in the repose position and the teeth come in a centric occlusion and the jaw in centric relationship and the artificial light was used when needed.

The patient should be subjected to clinical examination to confirm the special sample criteria. The clinical examination includes:

#### *2.2.2.1. Masticatory system examination*

After complete examination of occlusion, the same patient was subjected to the masticatory system examination to make sure that the patient is free from any signs and symptoms of temporomandibular joint disorders and all the informations were recorded in the same case sheet.

**Pullinger et al. (1985)** criteria were strictly followed in selecting the sample to ensure that the persons were completely asymptomatic. The criteria are:-

**1-** No pain or tenderness on palpation of the dorsal or lateral aspect of TMJ.

**2-** No pain on mandibular opening or excursive movement.

**3-** No pain on palpation of the muscles of mastication.

**4-** Normal range of mandibular opening ($\geq$ 40 mm) measured interincisally.

**5-** Normal lateral and protrusive movements are $\geq$ 7 mm **(Farrar, 1978)**.

The functional status of the masticatory system was examined in a systematic way as follow:

**A- Range of mandibular movements (Fig. 2.3)**

The inter-incisal distance was measured by a millimeter graded vernier. The patient was encouraged to open his mouth as wide as possible, then one end of the vernier was placed in the median plane against the incisal edge of one of the lower incisors and the distance to the incisal edge of the opposing upper incisor was measured to the nearest half of a millimeter, giving the inter-incisal distance on maximal opening in one vertical line. In open bite cases, the amount of negative overbite was subtracted from the maximal inter-incisal distance to give the maximal opening capacity of the mouth **(Schiffman et al., 1990)**.

Inter-incisal separation plus the incisal overlap in centric occlusion provides the measure of mandibular movement **(Blasberg and Greenberg, 2008).**

The maximum lateral movement was measured while the patient was in centric occlusion; measuring the displacement of lower midline from the facial midline. Then the patient was asked to move his mandible to the right as far as he or she could and the horizontal distance was measured by vernier to give the maximal lateral movement capacity to the right with adding lower midline displacement at the start of movement. In a similar manner, the maximal lateral movement capacity to the left was measured **(Okeson, 2003).**

The maximum protrusive movement represents distance between the labial surfaces of the upper and lower central incisors on maximal protrusion of the mandible plus the overjet **(Ingervall et al., 1980)**. In reversed overjet cases the negative overjet was subtracted from the distance between the labial surfaces of the incisors to give the maximal protrusion capacity. One end of the metric ruler was placed on the labial surface of an upper incisor and the horizontal distance to the labial surface of the lower incisor was measured to the nearest half of a millimeter, while the patient protruded his or her mandible as much as he or she could.

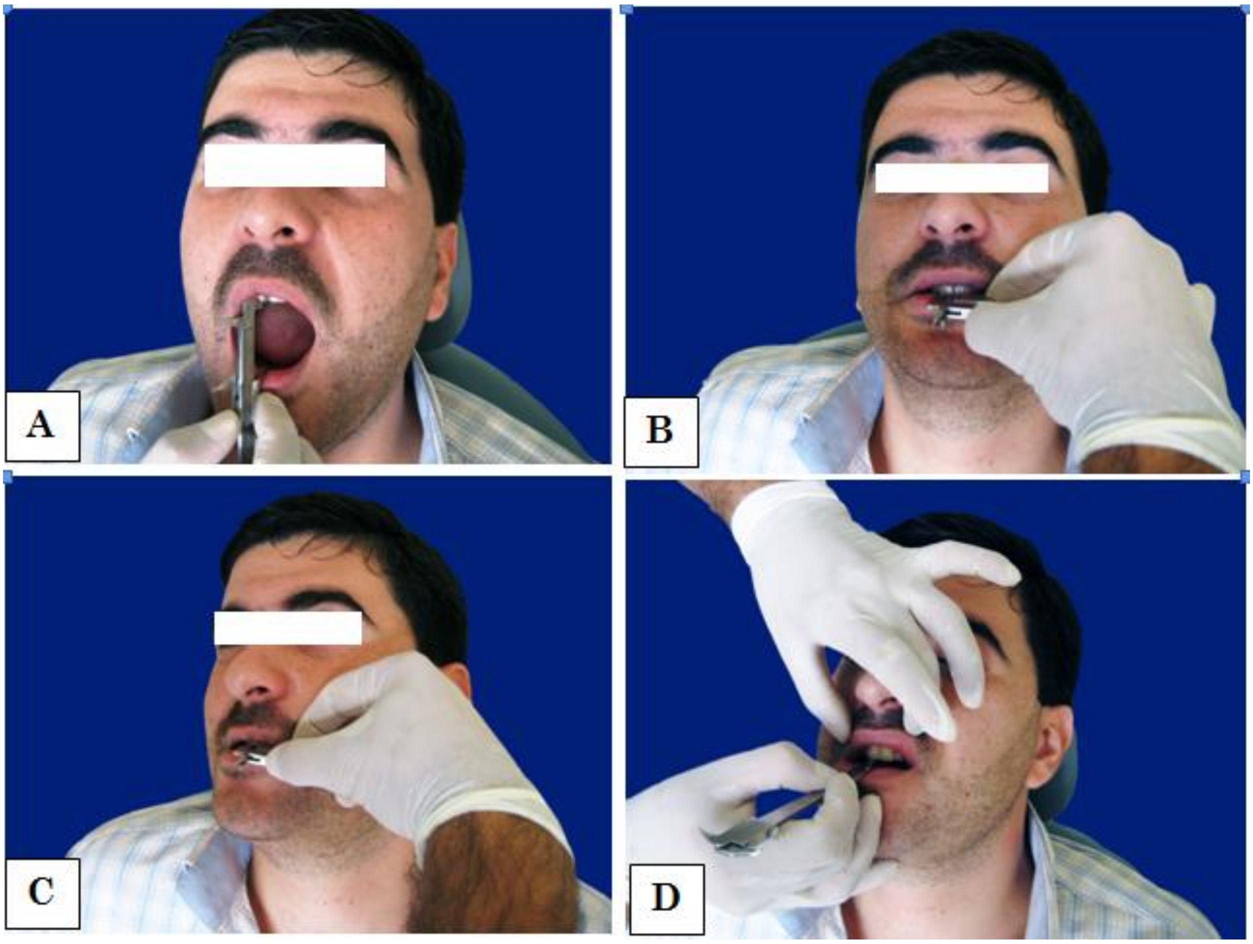



**Figure 2.3. Range of mandibular movements. A. Interincisal opening. B. C. Maximum lateral movements. D. Maximum protrusive movements.**

## B- Muscles palpation

Examination of muscles for tenderness is important because muscle tenderness is a possible sign of para-function **(Blasberg and Greenberg, 2008).**

➢ ***Masticatory muscles***

Examination of the masticatory muscles is an essential exercise in the evaluation of a temporomandibular disorder. As with all other findings, muscle tenderness may vary with the stage and progress of the disorder **(Gray et al., 2003)**.

The masticatory muscles were examined for tenderness and spasm using digital palpation. Both right and left sites were palpated extra-orally and simultaneously except for the lateral pterygoid and the insertion of the temporalis muscles which were palpated intra-orally and individually. Palpation was performed mainly by the palmer surface of the middle finger, with the index finger (forefinger) testing the adjacent areas. A single soft but firm pressure of 1 to 2 seconds duration was applied to the designated muscles, and the fingers were compressing the adjacent tissues in a small circular motion **(Okeson, 2003).**

Only if palpation produced a clear reaction of the patient (such as a palpebral reflex) or if the patient stated that the site palpated was clearly more tender to palpation than the surrounding structures or corresponding structures on the other side; this was assessed as muscle tenderness **(Helkimo, 1974).**

**1) Masseter muscle (Fig. 2.4 A, B)**

The Masseter was palpated bimanually by placing one finger intra-orally and the other on the cheek. The Masseter originates from the anterior two-thirds of the zygomatic arch and inserts into the outer aspect of the angle of the mandible **(Gray et al., 2003).**

**2) Lateral pterygoid muscle (Fig. 2.4 D)**

It was palpated by placing the index finger in the maxillary buccal vestibule and the patient is instructed to move the mandible towards the side being palpated to gain better access through the shifting of the coronoid process. The palmer surface of the index finger is moved posteriorly, superiorly and medially into the area of the infra-temporal fossa, posterior to the maxillary tuberosity **(Gray et al., 2003).**

**3) Medial pterygoid muscle (Fig. 2.4 C)**

It was palpated intra-orally at its insertion on the medial surface of the mandibular angles **(Gray et al., 2003).**

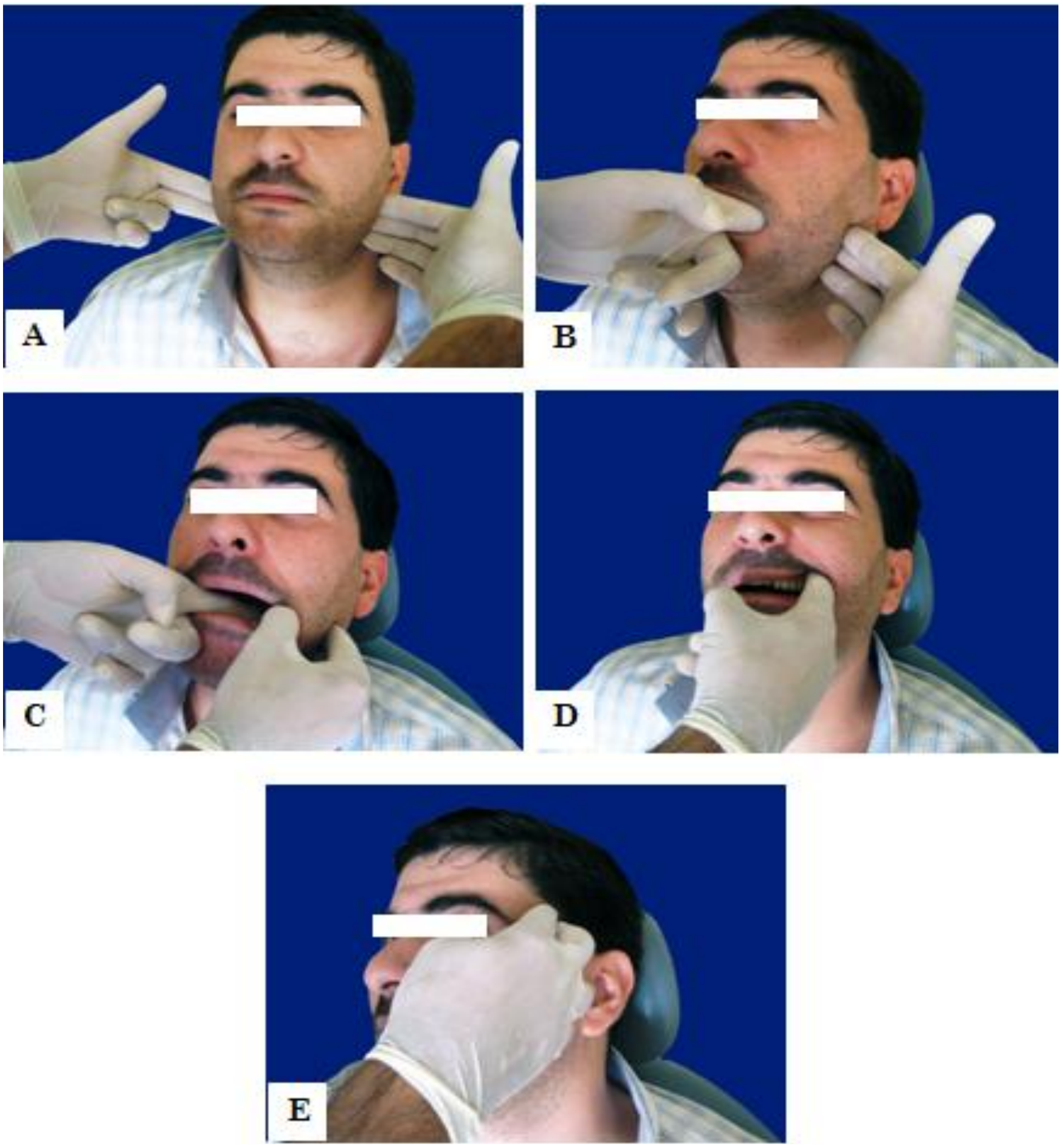



**Figure 2.4. Muscles palpation. A, B. Masseter. C. Medial pterygoid. D. Lateral pterygoid. E. Temporalis.**

### 4) Temporalis muscle (Fig. 2.4 E)

Insertion of the temporalis muscle in the coronoid process was palpated by placing the finger of one hand intra-orally on the anterior border of the ramus of the mandible and the finger of the other hand extra-orally on the same area. The fingers are moved simultaneously up the anterior border of the ramus until the coronoid process and the tendons are palpated. Anterior part of the temporalis muscle was palpated above the zygomatic arch and anterior to the TMJ, while the posterior part was palpated on the side of the head above and behind the ears **(Gray et al., 2003)**.

➢ **Cervical muscles (Fig. 2.5 A, B)**

Patients with temporomandibular dysfunction syndrome often have musculo-skeletal problems in other regions, particularly the neck **(Clark et al., 1987; Blasberg and Chalmers, 1989).** Sternocleidomastoid muscle was palpated by squeezing the muscle by using the thumb and forefingers, while the trapezious muscle was palpated by applying pressure by forefingers on the top of the muscle (**Johnstone and Templeton, 1980).**

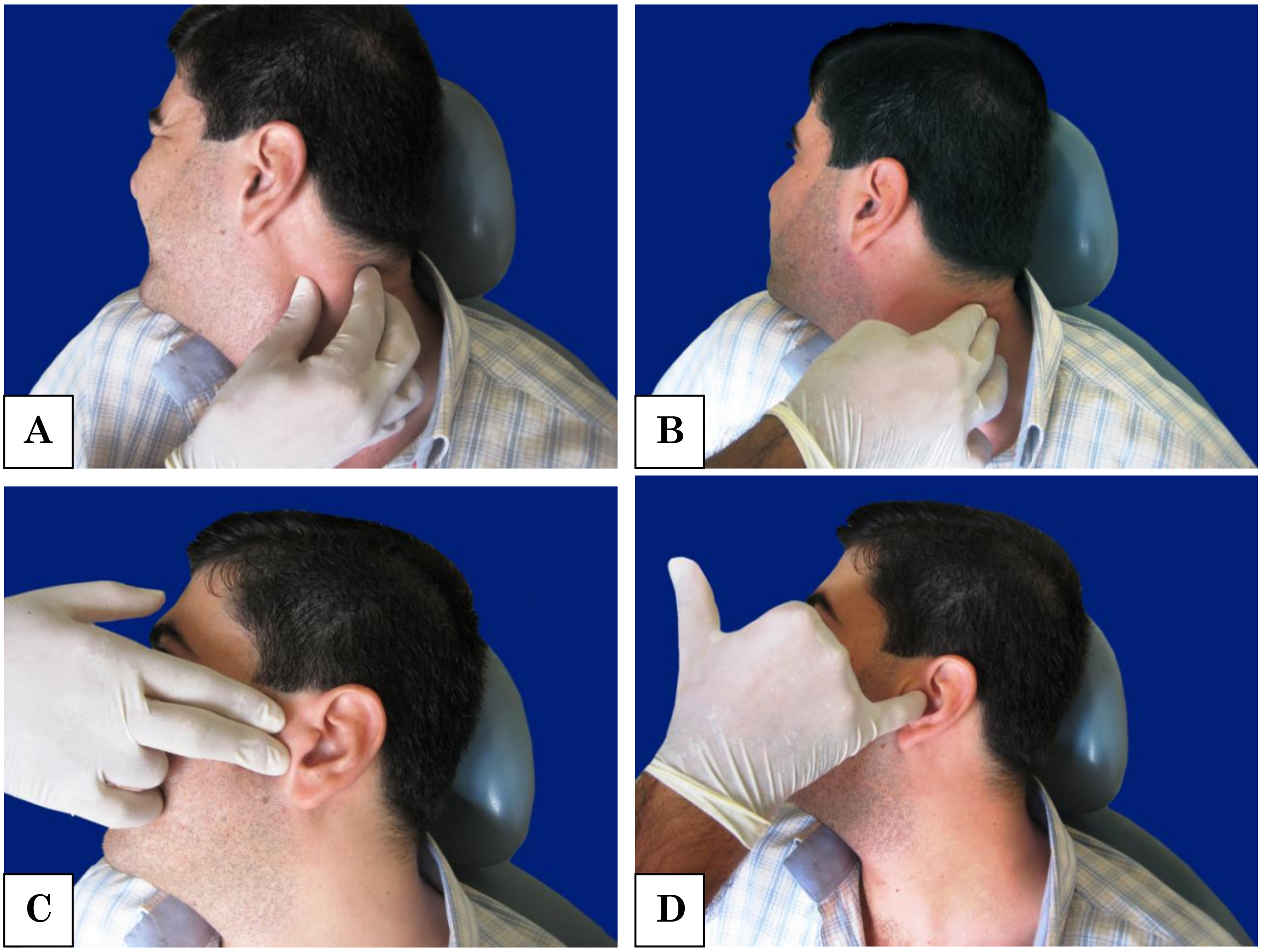



**Figure 2.5. Palpation of, A. Sternocleidomastoid muscle. B. Trapezius muscle. C. Lateral aspect of TMJ. D. Posterior aspect of TMJ.**

**C- TMJ palpation (Fig. 2.5 C, D)**

Tenderness of the posterior aspect of the TMJs was determined by placing the small finger of each hand into the external auditory meatus and applying forward pressure while the patient keeping his teeth in centric occlusion. Lateral palpation of the joints (pre–auricular area) was accomplished by pressing against and encircling both condylar heads simultaneously with the middle finger tips as the patient opens and closes his or her mouth. Only clear reactions of the patient were registered as positive results **(Gray et al., 2003).**

**D- Examination of pain on mandibular movements**

The patient was asked to systematically perform different movements of the mandible and report any pain felt during these movements i.e. opening, closing, protrusion, lateral movements to the right and left. In doubtful cases the movements were repeated against resistance of the examiner's hand **(Helkimo, 1974)**.

### *2.2.3. Patients preparation for radiographs*

The patients were prepared for the exposure by asking them to remove any spectacles, hearing aids, and personal jewellery such as ear rings, necklaces, and hairpins, these entire things may affect on the important anatomical landmarks like ear ring may cover the Articulare point.

Each patient’s mandible was positioned in centric relation by mandibular manipulation before the cephalogram was obtained. The chin was guided into its most posterior position and was able to move freely vertically in this "terminal hinge position" **(Rosenstiel et al., 1988).**

#### 2.2.3.1. *X-Ray technique*

##### 2.2.3.1.1. *Lateral cephalometric exposure*

The patient was positioned within the cephalostat with the sagittal plane of the head vertical, the Frankfort plane horizontal (determined visually) and the teeth were in centric occlusion. The correct exposure parameters for the individual being X-rayed were selected according to the **User's manual (2004)** as shown in Table2.1.

**Table 2.1: Lateral view exposure values (User's manual, 2004).**

| Patient | kV Value | mA Value |
|---|---|---|
| Adult female or small male | 68 | 5 |
| Adult male | 70 | 5 |
| Large adult male | 72 | 5 |

The height adjusting buttons were used to adjust the height of the cephalostat until the positioning cones at the ends of the ear posts are level with the patient's ears. The patients were positioned between the two ear posts so that the patient is facing the nasal positioner. Then the operator pressed the release lever on the side of the left-hand ear post holder and very carefully slid the positioning cones into the patient's ears.

The operator slid the nasal positioner towards the patient until it touches the patient's nasion and then, by sliding the nasal positioner up or down, adjusted the angle of the patient's head until the Frankfort plane is horizontal and parallel to the floor.

When the patient is ready to take an exposure, the operator touched the Ready field on the main display. The unit moves to the ready position for the selected exposure program. A green indicator light comes on the exposure button and on the control panel. Additionally, the word READY shows on the control panel. While the unit moves to the ready position the green indicator lights and the word READY flashes. The flashing stops when the unit reaches the ready position. The operator asked the patient to stand as still as possible, then pressing and holdingdown the exposure button on the remote control for the duration of the exposure.

During the exposure period the radiation warning lights on the exposure switch and on the control panel came on and the operator heard the radiation warning tone. When the radiation warning tone stops, the ear posts can be slid out and the patient can be guided from the unit. When operator took the exposure the image was showed on the computer screen. Note that operator accepted the image by clicking the "OK" button – only accepted images were stored in the database **(User's Manual, 2004).**

#### *2.2.3.1.2. Orthopantomograph exposure*

The patient was guided to the unit and the height of the unit was adjusted to the level of patient's mouth so that he/she grasped the patient handles facing the chin support then he/she bit on the slot in the arm attached to chin support.

Patient’s head was positioned so that the mid-sagittal plane coincides with the mid-sagittal plane light beam and Frankfort plane is parallel to the Frankfort plane light as a reference line. The operator advised the patient to look straight ahead as the light may appear to be correctly positioned then the operator selected the exposure value (Table 2.2) and the arch form of each patient for best clarification of the x-ray.

When the patient was ready to take an exposure, the operator touched the Ready field on the main display so that the unit moved to the ready position. On the exposure button and on the control panel a green indicator light comes on and flashes, then the Dimaxis program shows the Waiting for Ready message on the computer screen, then The Dimaxis program shows the Waiting for Exposure message on the computer screen.

The patient was asked to stand as still as possible. The operator moved to a protected area, pressed and held down the exposure button for the duration of the exposure. When the exposure is finished, the image was shown on the computer screen, note that the operator accepted the image by clicking the "O.K" button, only accepted images was stored in the database **(User's Manual, 2004).**

**Table 2.2: Orthopantomograph exposure values (User's manual, 2004).**

| Patient | kV Value | mA Value |
|---|---|---|
| Adult female or small male | 64 | 7 |
| Adult male | 66 | 8 |
| Large adult male | 68 | 9 |

### *2.2.4. Cephalometric Analysis (Fig. 2.6)*

Every lateral cephalometric radiograph was analyzed by AutoCAD program 2008 to calculate the angular and linear measurements. The angles were measured directly as they were not affected by magnification, while the linear measurements were divided by scale for each picture to overcome the magnification.

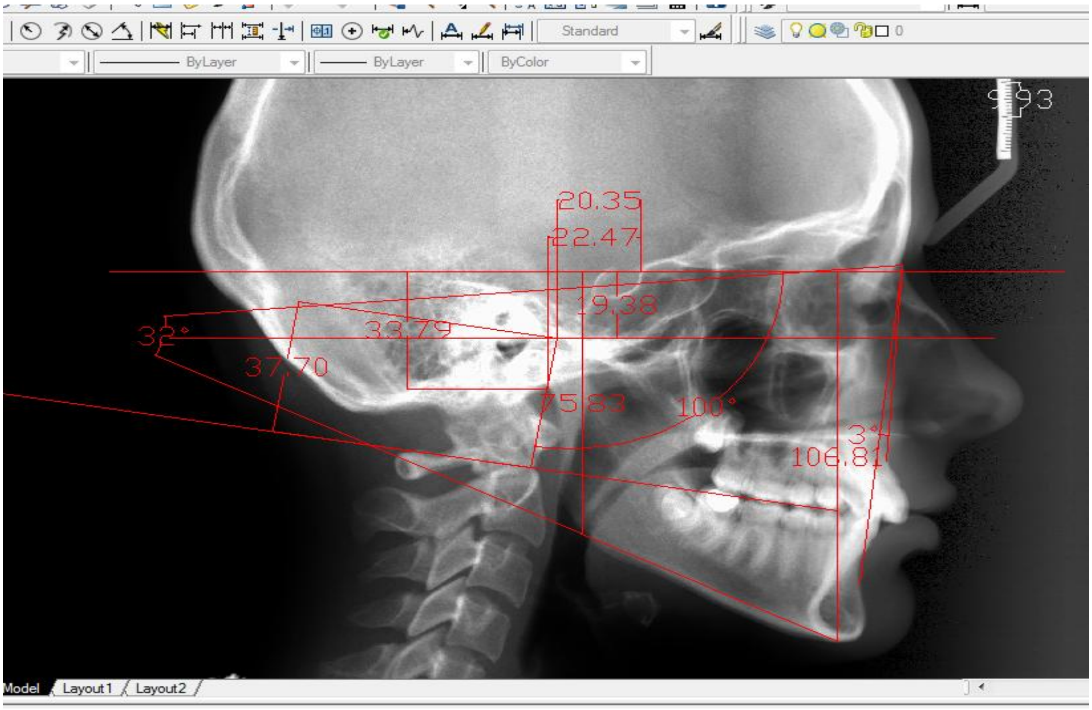



Figure 2.6. Cephalometric measurements

### *2.2.4.1. Cephalometric points*

The bony cephalometric points included the followings (Fig. 2.7A):

1. **Point A (Subspinale)**: The deepest midline point on the premaxilla between the Anterior Nasal Spine and Prosthion **(Downs, 1948)**.
2. **Point B (Supramentale)**: The deepest midline point on the mandible between Infradentale and Pogonion **(Downs, 1948)**.
3. **Point S (Sella)**: The midpoint of the hypophysial fossa **(Rakosi, 1982)**.
4. **Point N (Nasion)**: The most anterior point on the naso-frontal suture in the median plane **(Rakosi, 1982)**.
5. **Point T:** It is the most superior point of the anterior wall of sella turcica (**Viazis, 1991**).
6. **Point Ar (Articulare):** A point at the junction of the posterior border of the ramus and the inferior border of the posterior cranial base (occipital bone). (**Caufield, 1995)**.
7. **Point Go (Gonion)**: A point on the curvature of the angle of the mandible located by bisecting the angle formed by the intersection of the lines tangent to the posterior ramus and the inferior border of the mandible (**Caufield, 1995)**.
8. **Point Me (Menton)**: The lowest point on the symphyseal shadow of the mandible seen on a lateral cephalogram **(Caufield, 1995)**.
9. **Point Fs (Fossa summit)**: It is the point on the superior margin of the glenoid fossa where a line parallel to SBL (Stable Basicranial Line) tangent to the superior curvature of Glenoid Fossa **(Baccetti et al., 1997)**.
10. **Fs':** It’s the projection of point Fs on SBL **(Viazis, 1991)**.
11. **Ar':** It’s the projection of point Ar on SBL **(Baccetti et al., 1997)**.

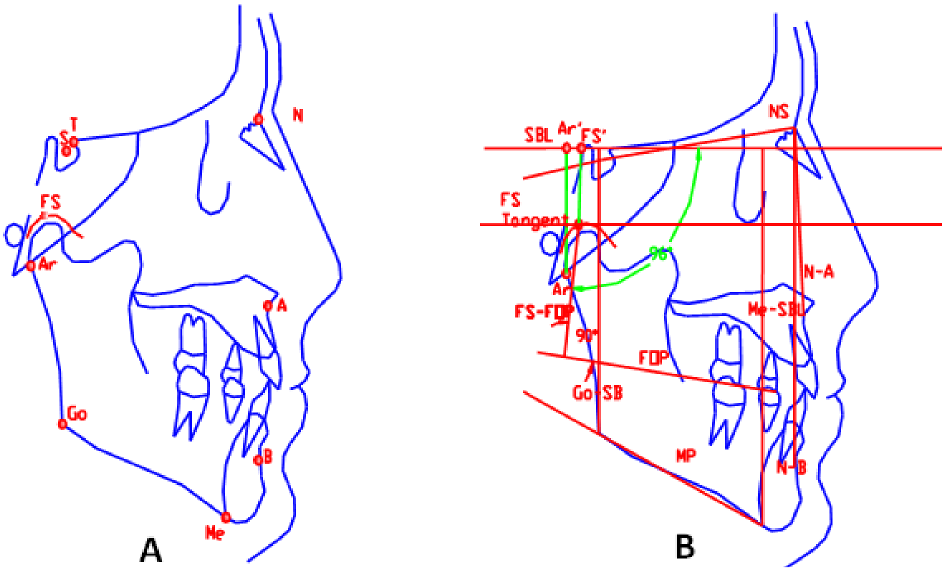



**Figure 2.7. Cephalometric points (A) and planes(B)**

### 2.2.4.2. *Cephalometric Planes*

The following cephalometric planes were determined (Figure 2.7 B):

1. **Sella-Nasion (SN) plane**: It is the anteroposterior extent of anterior cranial base **(Rakosi, 1982)**.
2. **Mandibular plane (MP)**: Formed by a line joining Gonion and Menton **(Rakosi, 1982)**.
3. **N- A line**: Formed by a line joining Nasion and point A **(Downs, 1948)**.
4. **N- B line**: Formed by a line joining Nasion and point B **(Downs, 1948)**.
5. **Functional occlusal plane (FOP):** A plane formed by bisecting the intercuspation of the first premolars anteriorly and the intercuspation of the first molars posteriorly **(Riolo et al., 1974)**.
6. **SBL** (**Stable Basicranial Line)**: It is the line passing through point T and tangent to the lamina cribrosa of the ethmoid bone (**Tollaro et al., 1995)**.

### 2.2.4.3. *Cephalometric measurements*

The following angles and linear measurements were recorded to the nearest degree and millimeters respectively:

## A. Sagittal measurements

1. **ANB angle**: The angle between lines N-A and N-B. It represents the difference between SNA and SNB angles or it may be measured directly as the angle ANB. It is the most commonly used measurement for appraising anteroposterior disharmony of the jaws **(Riedel, 1948, 1952; Steiner, 1953)**.

2. **T-Fs'**: The linear distance from point T to point Fs' (**Viazis, 1991**).

3. **T-Ar'**: The linear distance from point T to point Ar' **(Baccetti et al., 1997).**

T-Fs' and T-Ar' are very important variables that have been depended on to determine the sagittal position of glenoid fossa.

## B. Vertical measurements

1. **MP-SN angle:** the inclination of the mandibular line to the nasion-sella line **(Schudy, 1964).**

2. **Fs-Fs':** The linear distance from point Fs to point Fs' **(Baccetti et al., 1997).**

3. **Ar-Ar':** The linear distance from point Ar to point Ar' **(Baccetti et al., 1997).** Fs-Fs' and Ar-Ar' are very important variables that have been depended upon to determine the vertical position of glenoid fossa.

4. **Go- SBL:** The perpendicular distance from SBL to point Gonion **(Baccetti et al., 1997).**

5. **Me-SBL:** The perpendicular distance from SBL to point Menton **(Baccetti et al., 1997).**

6. **Fs-Fop:** It’s the perpendicular distance from point Fs to the FOP **(Devised by the author)**.

7. **Fs-SBL°:** It is the angle between the FS-Fop and SBL **(Devised by the author)**. This angle defined the relationship between glenoid fossa and the functional occlusal plane.

### 2.2.5. Calibration Procedure

To assess the validity of the measurements, intra-examiner calibration was done, by the same operator with time elapse of one month between the two examinations, by repeating the same procedures of importing the image to the AutoCAD program, correction of magnification, landmarks identification, drawing the planes, and measuring the angular and linear parameters on 10 randomly selected lateral cephalometric radiographs. The inter-examiner calibration was carried out by repeating the same procedures on the same radiographs by a well- trained orthodontist. The results revealed non-significant differences between the first and second readings for intra-examiner and inter-examiner calibration at 0.05 probability level by using paired samples t-test (Table 2.3).

**Table 2.3.** Intra -and Inter-examiner calibration

| Variables | Intra-examiner calibration (N=10, d.f.=9) | | | Inter-examiner calibration (N=10, d.f.=9) | | |
|---|---|---|---|---|---|---|
| | Mean difference | t-test | *P*-value | Mean difference | t-test | *P*-value |
| ANB angle | 0.1 | 0.56 | 0.6 | -0.2 | -1 | 0.34 |
| MP-SN angle | 0.2 | 0.56 | 0.59 | 0.5 | 0.9 | 0.36 |
| T-Fs’ (mm.) | 0.008 | 0.68 | 0.51 (NS) | 0.01 | 1.05 | 0.32 (NS) |
| T-Ar’(mm.) | 0.005 | 0.47 | 0.64 (NS) | -0.004 | -1 | 0.34 (NS) |
| Fs-Fs'(mm.) | 0.011 | 1.71 | 0.11 (NS) | 0.014 | 1.2 | 0.26 (NS) |
| Ar-Ar' (mm.) | 0.001 | 0.06 | 0.95 (NS) | 2.004 | 1.51 | 0.16 (NS) |
| Fs-Fop (mm.) | 0 | 0 | 1 (NS) | -0.015 | -0.71 | 0.49 (NS) |
| Fs-SBL (degree) | 0.001 | 0.36 | 0.72 (NS) | -0.005 | -1.34 | 0.21 (NS) |
| Me-SBL (mm.) | 0.007 | 0.58 | 0.57 (NS) | 0.002 | 0.34 | 0.73 (NS) |
| Go-SBL (mm.) | 0.004 | 0.56 | 0.58 (NS) | 2.694 | 0.99 | 0.34 (NS) |

### *2.2.6. Statistical analysis*

All the data of the sample were subjected to computerized statistical analysis using SPSS version 15 (2006) computer program. The statistical analysis included:

1. Descriptive statistics; including mean, standard deviation, and statistical tables and figures.
2. Inferential statistics including;

- One way ANOVA test: to compare the glenoid fossa position in different sagittal and vertical skeletal groups.
- Least significant difference (LSD) test: after ANOVA test to detect significance of difference between every two groups.
- Pearson's correlation coefficient: to find the relation between glenoid fossa position and the other measured variables.

In the statistical evaluation, the following levels of significance are used:

| | | |
|---|---|---|
| $P > 0.05$ | NS | Non-significant |
| $0.05 \geq P > 0.01$ | * | Significant |
| $0.01 \geq P > 0.001$ | ** | Highly significant |
| $P \leq 0.001$ | *** | Very highly significant |

In the statistical evaluation, the following levels determine the strength of the relationship **(Betzenberger et al., 1999)**:

$|r| > 0.80$ the correlation is strong.

$|r| = 0.40 – 0.80$ the correlation is moderate.

$|r| < 0.40$ the correlation is weak.

# CHAPTER THREE

# 3. Results

## 3.1. The position of glenoid fossa in different anteroposterior relationships

Table 3.1 and Figure 3.1 show the descriptive statistics and classes comparison using one-way ANOVA test.

### *3.1.1. Angular measurement*

The results indicated that the mean value for FS-SBL angle in class III > class II > class I. ANOVA test revealed non-significant difference among the three classes.

### *3.1.2. Linear measurements*

**1. Sagittal measurements**

The results indicated that the mean value of T-Fs' and T-Ar' in class II > class I > class III. ANOVA test revealed the presence of significant difference in T-Fs' and T-Ar' among the classes. LSD test showed that there was a highly significant difference in T-Fs' and T-Ar' between class II and III and a non-significant difference between class I and II, class I and III (Table 3.2).

**2. Vertical measurements**

The results indicated that the mean value of the vertical distance Fs-Fs' in class I > class II > class III; while the mean value of Ar-Ar', Fs-Fop, Me-SBL and Go-SBL in class III > class I > class II. ANOVA test revealed significant difference in Me-SBL among the classes. LSD test clarified the presence of significant difference in Me-SBL between class I & III and class II & III (Table 3.2).

**Table 3.1.** Descriptive statistics and classes comparison using one-way ANOVA test

| Variables | Class I (N=48) | | | | Class II (N=41) | | | | Class III (N=35) | | | | ANOVA test (d.f.=123) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Min. | Max. | Mean | S.D. | Min. | Max. | Mean | S.D. | Min. | Max. | F-test | P-value |
| ANB° | 3.1 | 0.85 | 2 | 4 | 6.56 | 1.96 | 5 | 13 | -2.31 | 2.76 | -11 | 1 | 202.3 | 0.000 *** |
| T-FS' (mm) | 16.18 | 3.32 | 8.13 | 24.64 | 17.25 | 3.01 | 10.75 | 22.58 | 15.02 | 3.06 | 8.63 | 20.58 | 4.7 | 0.011 * |
| T-Ar' (mm) | 18.77 | 3.56 | 12.23 | 28.42 | 19.74 | 3.87 | 13.23 | 33.10 | 17.55 | 3.33 | 11.23 | 23.68 | 3.46 | 0.034 * |
| FS-FS' (mm) | 20.35 | 3.14 | 12.27 | 28.90 | 19.57 | 3.1 | 14.15 | 25.02 | 19.08 | 3.11 | 13.95 | 25.21 | 1.7 | 0.176 (NS) |
| Ar-Ar' (mm) | 34.19 | 3.57 | 24.72 | 41.29 | 34.12 | 3.75 | 25.86 | 44.60 | 34.39 | 4.14 | 26.40 | 41.89 | 0.04 | 0.952 (NS) |
| FS-FOP (mm) | 38.86 | 4.87 | 31.49 | 50.35 | 37.21 | 5.41 | 21.34 | 51.14 | 39.59 | 6.24 | 29.30 | 52.11 | 1.9 | 0.148 (NS) |
| FS-SBL° | 98.1 | 4.82 | 85 | 112 | 99.24 | 4.28 | 89 | 106 | 99.97 | 6.11 | 86 | 112 | 1.4 | 0.240 (NS) |
| Me-SBL (mm) | 106.71 | 8.81 | 89.72 | 129.72 | 106.55 | 8.23 | 86.38 | 125.13 | 111.07 | 9.32 | 89.37 | 127.43 | 3.2 | 0.044 * |
| Go-SBL (mm) | 79.41 | 6.94 | 68.41 | 97.09 | 78.15 | 6.92 | 66.64 | 93.95 | 80.78 | 8.23 | 67.98 | 94.95 | 1.22 | 0.29 (NS) |

**Table 3.2.** LSD test between every two significant groups

| Variables | Class I- Class II | | Class I- Class III | | Class II- Class III | |
|---|---|---|---|---|---|---|
| | Mean difference | P-value | Mean difference | P-value | Mean difference | P-value |
| ANB° | -3.456 *** | 0.000 | 5.418 *** | 0.000 | 8.875 *** | 0.000 |
| T-FS' (mm) | -1.063 (NS) | 0.11 | 1.160 (NS) | 0.1 | 2.223 ** | 0.003 |
| T-Ar' (mm) | -0.965 (NS) | 0.21 | 1.219 (NS) | 0.13 | 2.185 ** | 0.01 |
| Me-SBL (mm) | 0.158 (NS) | 0.93 | -4.364 * | 0.03 | -4.522 * | 0.03 |

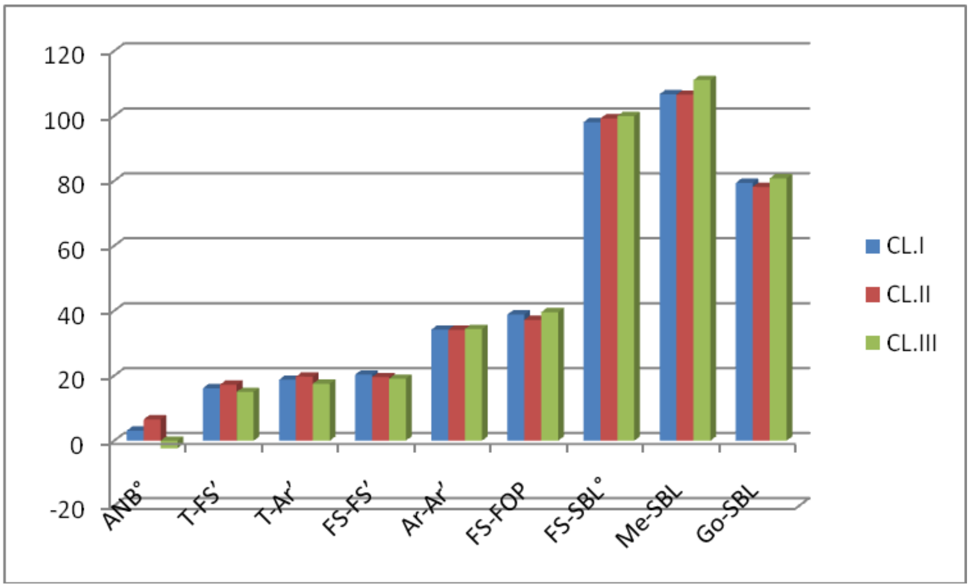



Figure 3.1 Bar chart of descriptive statistics for different classes

### *3.1.3. The relationship between the anteroposterior position of glenoid fossa and the measured variables*

Table 3.3 shows the correlation between the anteroposterior positions of glenoid fossa and the measured variables. The results indicated that there was direct significant weak correlation between the sagittal position of glenoid fossa (T-Fs') and ANB angle only, otherwise T-FS' and T-Ar' showed non-significant correlation to the measured variables.

**Table 3.3.** Correlation between the sagittal position of glenoid fossa and measured variables.

| Variables | | ANB° | Go-SBL (mm) | Me-SBL (mm) | FS-SBL° | FS-FOP (mm) | Ar-Ar' (mm) | FS-FS' (mm) |
|---|---|---|---|---|---|---|---|---|
| T-FS' (mm) | r | 0.228 * | 0.046 (NS) | -0.07 (NS) | 0.007 (NS) | -0.04 (NS) | -0.02 (NS) | 0.01 (NS) |
| | P | 0.011 | 0.61 | 0.38 | 0.93 | 0.67 | 0.78 | 0.9 |
| T-Ar' (mm) | r | 0.17 (NS) | 0.10 (NS) | -0.07 (NS) | -0.06 (NS) | 0.018 (NS) | 0.03 (NS) | 0.06 (NS) |
| | P | 0.06 | 0.26 | 0.41 | 0.52 | 0.84 | 0.73 | 0.52 |

## 3.2. The position of glenoid fossa in different vertical relationships

Table 3.4 and Figure 3.2 show the descriptive statistics and classes comparison using one-way ANOVA test.

### *3.2.1. Angular measurements*

The results indicated that the mean value of FS-SBL angle in high angle > normal angle > low angle. ANOVA test revealed very highly significant difference among the vertical groups. LSD test indicated that Fs-SBL angle showed very high significant difference between normal, high and low angle groups (Table 3.5).

### *3.2.2. Linear measurements*

**1. Sagittal measurements**

The results indicated that the mean value of T-Fs' in normal angle > low angle > high angle and T-Ar' in low angle > normal angle > high angle. ANOVA test revealed non-significant difference among normal angle, high angle and low angle groups.

**2. Vertical measurements**

The results indicated that the mean value of Fs-Fs', Ar-Ar' and Go-SBL in low angle > normal angle > high angle, while Fs-Fop in low angle > high angle > normal angle and Me-SBL in high angle > low angle > normal angle. ANOVA test revealed that there was very highly significant difference in Fs-Fs', Me-SBL and Go-SBL, while in Ar-Ar' showed highly significant difference, on the other hand, Fs-Fop showed significant difference among groups. LSD test between groups showed that there was highly significant difference in Fs-Fs' between normal and high angle, significant difference between normal and low angle, very highly significant between high and low angle, while Ar-Ar' showed significant difference between normal and high angle, non-significant difference between normal and low angle and highly significant difference between high and low angle, on the other hand, Fs-Fop showed non-significant difference between normal and high angle and high and low angle, highly significant difference between normal and low angle. Me-SBL showed very highly significant difference between normal and high angle, non-significant difference between normal and low angle and highly significant difference between high and low angle, while Go-SBL showed significant difference between normal and high angle and very highly significant difference between normal and low angle and high and low angle (Table 3.5).

**Table 3.4.** Descriptive statistics and group comparison using one-way ANOVA test.

| Variables | Normal (N=67) | | | | High Angle (N=23) | | | | Low Angle (N=34) | | | | ANOVA test (d.f.=123) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Min. | Max. | Mean | S.D. | Min. | Max. | Mean | S.D. | Min. | Max. | F-test | P-value |
| MP-SN° | 34.41 | 2.9 | 30 | 40 | 45.86 | 4.75 | 41 | 58 | 25.47 | 2.67 | 18 | 29 | 268.19 | 0.000 *** |
| T-FS' (mm) | 16.07 | 3.72 | 6.95 | 24.64 | 14.99 | 3.12 | 9.60 | 19.94 | 15.97 | 2.54 | 11.07 | 21.58 | 0.93 | 0.397 (NS) |
| T-Ar' (mm) | 18.44 | 3.95 | 8.77 | 28.42 | 17.34 | 3.16 | 11.59 | 22.45 | 19.12 | 3.16 | 12.77 | 26.86 | 1.67 | 0.192 (NS) |
| FS-FS' (mm) | 19.71 | 2.93 | 13.95 | 28.90 | 17.68 | 3.19 | 12.27 | 24.54 | 21.16 | 2.78 | 15.15 | 25.21 | 9.64 | 0.000 *** |
| Ar-Ar' (mm) | 34.22 | 3.15 | 28.99 | 42.36 | 32.34 | 4.17 | 25.86 | 40.40 | 35.5 | 4.16 | 24.72 | 44.60 | 5.14 | 0.007 ** |
| FS-FOP (mm) | 37.36 | 5.34 | 21.34 | 50.85 | 38.81 | 5 | 29.50 | 50.23 | 40.61 | 5.65 | 31.51 | 52.11 | 4.17 | 0.018 * |
| FS-SBL° | 99.26 | 4.1 | 89 | 110 | 103.08 | 4.53 | 94.00 | 112.00 | 95.73 | 5.1 | 85 | 105 | 18.75 | 0.000 *** |
| Me-SBL (mm) | 106.24 | 8.07 | 86.38 | 129.72 | 114.22 | 7.36 | 97.30 | 125.77 | 106.86 | 9.8 | 89.37 | 127.43 | 7.94 | 0.001 *** |
| Go-SBL (mm) | 78.51 | 6.53 | 66.82 | 97.09 | 74.9 | 6.03 | 66.64 | 91.13 | 84.12 | 7.22 | 71 | 96.03 | 14.48 | 0.000 *** |

**Table 3.5.** LSD test between every two significant groups.

| Variables | Normal –high angle | | Normal –low angle | | High angle-low angle | |
|---|---|---|---|---|---|---|
| | Mean difference | P-value | Mean difference | P-value | Mean difference | P-value |
| MP-SN° | -11.451 *** | 0.000 | 8.947 *** | 0.000 | 20.39 *** | 0.000 |
| FS-FS' (mm) | 2.037 ** | 0.005 | -1.45 * | 0.021 | -3.487 *** | 0.000 |
| Ar-Ar' (mm) | 1.888 * | 0.034 | -1.272 (NS) | 0.1 | -3.161 ** | 0.002 |
| FS-FOP (mm) | -1.456 (NS) | 0.264 | -3.251 ** | 0.005 | -1.794 (NS) | 0.218 |
| FS-SBL° | -3.818 *** | 0.001 | 3.533 *** | 0.000 | 7.351 *** | 0.000 |
| Me-SBL (mm) | -7.975 *** | 0.000 | -0.615 (NS) | 0.731 | 7.36 ** | 0.002 |
| Go-SBL (mm) | 3.612 * | 0.026 | -5.615 *** | 0.000 | -9.227 *** | 0.000 |

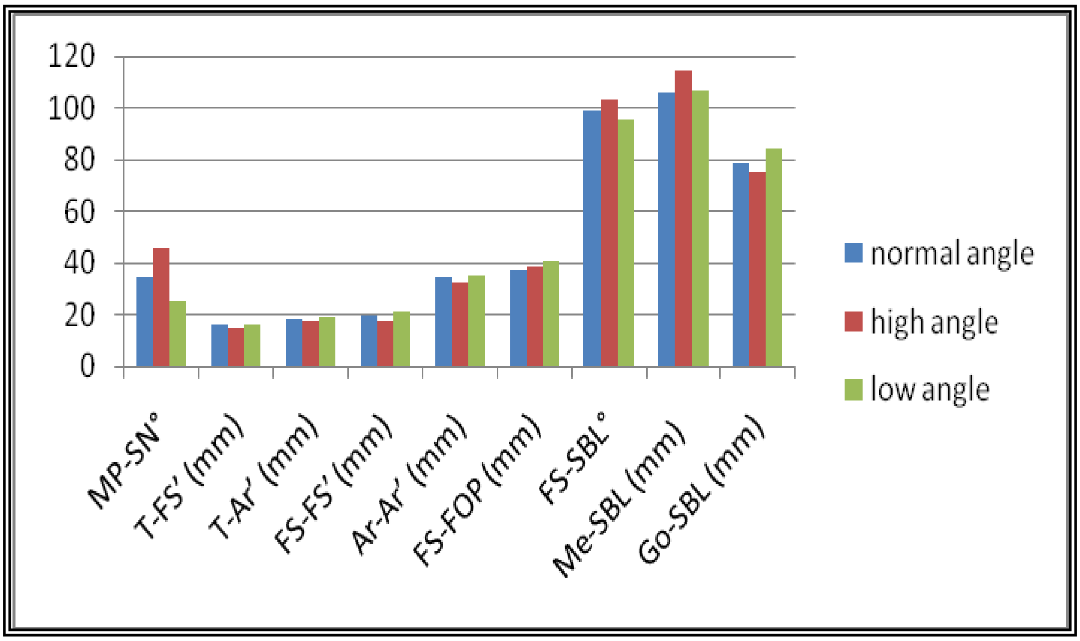



Figure 3.2 Bar chart of descriptive statistics for vertical groups

### *3.2.3. The relationship between the vertical position of glenoid fossa and the measured variables*

Table 3.6 shows the correlation between the vertical positions of glenoid fossa and the measured variables. The results indicated that there was direct moderate very highly significant correlation between the vertical positions of glenoid fossa Fs-Fs', Ar-Ar' and the Go-SBL, while there was indirect weak very highly significant correlation between the vertical positions and Fs-SBL and indirect weak and moderate very highly significant correlations between MP-SN angle and Ar-Ar' and Fs-Fs' respectively. On the other hand, there was non-significant correlation between the Fs'-Fs' and Me-SBL, FS-FOP and T-Fs', while there was direct weak highly significant correlation between Ar'-Ar' and FS-FOP, on the other hand there was non-significant correlation between Ar'-Ar' and T-Fs' and T-Ar'. In addition to direct weak highly significant correlation between Ar-Ar′ and Me-SBL, and direct moderate very highly significant correlation between Fs-Fs′ and T-Ar′.

**Table 3.6.** Correlation between vertical position of glenoid fossa and measured variables.

| Variables | | Go-SBL (mm) | Me-SBL (mm) | FS-SBL° | FS-FOP (mm) | MP-SN° | T-Fs' (mm) | T-Ar' (mm) |
|---|---|---|---|---|---|---|---|---|
| **FS-FS' (mm)** | **r** | **0.53 ***** | **0.13 (NS)** | **-0.36 ***** | **-0.02 (NS)** | **-0.42 ***** | **0.127 (NS)** | **0.55 ***** |
| | **P** | **0.000** | **0.13** | **0.000** | **0.84** | **0.000** | **0.158** | **0.000** |
| **Ar-Ar' (mm)** | **r** | **0.64 ***** | **0.24 **** | **-0.31 ***** | **0.02 **** | **-0.34 ***** | **0.02 (NS)** | **0 (NS)** |
| | **P** | **0.000** | **0.006** | **0.000** | **0.008** | **0.000** | **0.81** | **0.99** |

# CHAPTER FOUR

# 4. Discussion

## 4.1. Sample

The sample of this research is characterized by certain predetermined properties that serve to derive the proper result regarding the position of glenoid fossa in relation to different skeletal patterns, and by excluding the relation between temporomandibular joint disorders and glenoid fossa position. Some authors have found a high association between posteriorly or anteriorly positioned glenoid fossa and different loading within TMJs **(Hylander, 1992; Ueki et al., 2008)**, so that the sample was selected with specific age and certain criteria due to the following reasons:

1. The sample was selected at age between eighteen and thirty years old to minimize the effect of any remaining skeletal growth **(Sinclair and Little, 1985)** as the majority of facial growth is usually complete by 16-17 years of age **(Jones and Oliver, 2000).** The advantage of that is to confirm that the relation between T.M.J and different skeletal patterns is not affected by the growth.
2. Loss of posterior tooth support may increase the vertical loading on the joints, for that reason the extraction cases were excluded from this study.
3. A posterior unilateral supra-contact or initial contact from a high restoration may create a frontal plane tipping of the jaw, compressing one joint and tending to distract the other **(Tsukasa et al., 1986).**
4. Previous orthodontic treatments, especially class II treated with Herbst appliance, may lead to remodeling in the glenoid fossa **(VanLaecken et al., 2006).**
5. Patients with symptomatic Osteoarthritis and Rheumatoid arthritis (degenerative joint disease) associated with a loss of articular osseous

tissues, soft tissues or both were excluded. This disease may lead to narrowing of the joint space, anterior posturing of the mandible, micrognathia (direct injury to the condylar head and altered orofacial muscular activity) and an increased difficultly in interpreting the osseous margins if erosions occur in these margins **(Larheim, 1981; Hatcher, 1983; Boering et al., 1990)**.

Generally, the sample was classified according to sagittal (ANB angle) and vertical (MP-SN angle) skeletal relations into three groups for each type. ANB angle provides information about the relative position of the jaws, or the anteroposterior discrepancies of maxillary to mandibular bases. The mean value for skeletal classes agreed with **Droel and Isaacson (1972)**, **Odeh (1989)**, **Al-Sahaf (1991)**, **Kinaan et al. (1993)** and **Baccetti et al.** (**1997)**. The MP-SN angle is a measurement known to be reliable in the assessment of vertical proportions. The mean value for vertical groups agreed with **Droel and Isaacson** (**1972**) and **Baccetti et al**. (**1997**). The close agreement of these angles in the present study with the studies mentioned above revealed the similar methodology applied in the material and method especially the landmark identification.

## 4.2. The position of GF in different anteroposterior relationships

### *4.2.1. Angular measurements*

❖ **Fs-SBL angle**

This angle defined the relationship between glenoid fossa and the functional occlusal plane. The mean value of this angle was nearly similar in the different skeletal classes. ANOVA test revealed a non-significant difference; this reflects a fact that the sagittal position of glenoid fossa is weakly influenced by the anteroposterior skeletal relationship. The possible explanation for this result may be: the cant of FOP is weakly affected by the sagittal skeletal relation due to the absence of clockwise or anticlockwise rotations, i.e. mostly it's nearly flat in the sagittal skeletal patterns. **Braun et al.** (**2000**) used different reference points to clarify this angle, they used the SBL as that line away from S-N plane by 7˚ and the method of circles on template to determine the geometric center of glenoid fossa from which perpendicular line projected on FOP, they found that there was a significant difference in this angle between class II and III in male group only, while in the present study T point was used to define SBL, and the fossa summit point was projected on the FOP to form the Fs-FOP which contributed with SBL to form this angle.

### *4.2.2. Linear measurements*

**1. Sagittal measurements**

❖ **T-FS' and T-Ar'**

They are very important variables that have been depended on to determine the sagittal position of glenoid fossa.

The results revealed that the mean values of these two variables were slightly higher in class II than class I and III, and there is highly significant difference only between CL.II and CL.III that means the sagittal position of glenoid fossa in class II was more posterior than in class III. These results come in accordance with **Droel and Isaacson (1972)** although they used a different reference point (point S) for the assessment of the sagittal position of the glenoid fossa. In the present study, point T was used instead of point S. Point T was chosen in order to avoid uncontrolled variability of the reference structures due to the remodeling of the floor and of the posterior wall of sella turcica along with growth **(Melsen, 1974)**. Moreover, **Baccetti et al.** (**1997**) used the same reference point and the results in this study agreed with them. The inclusion of SNA and SNB angles in future studies may present an explanation for these results.

**Giuntini** ***et al***. (**2008**) found more distal position of glenoid fossa in class II while **Innocenti et al. (2009)** found more mesial position of glenoid fossa in class III, both of them depended on GF-FMN (Frontomaxillary Nasal suture) as a reference line, also the results in this study agreed with them although the reference line was different.

## 2. Vertical measurements

### ❖ FS-FS' and Ar-Ar'

These variables are important measurements that have been depended upon to determine the vertical position of glenoid fossa. The results revealed the close similarity of the mean values of these variables with a non-significant difference among the classes as shown by ANOVA test; this comes in agreement with **Baccetti et al. (1997).**The results may be attributed to the nearly similar posterior facial height of the classes subjects, or nearly similar mandibular rotation.

### ❖ FS-FOP

This vertical distance connects the glenoid fossa position to functional occlusal plane. The result indicated that this distance did not differ significantly in different sagittal skeletal classes. **Braun et al. (2000)** found significant difference in this distance between class II and III in male group only. This difference in results may be attributed to different landmarks used and to the effect of dentoalveolar compensation.

### ❖ Me-SBL

This vertical distance correlates the point menton to the base of skull. The result revealed that the mean value of this variable was nearly similar in class I and II and higher in class III with a significant difference between the classes as indicated by ANOVA test. LSD test revealed that there was a significant difference between class I and III and between class II and III. **Baccetti et al. (1997)** found that this variable was nearly similar in different sagittal skeletal classes with a non-significant difference; the difference in the results may be attributed to the difference in the age groups as **Baccetti et al.** took their sample with an age ranged between 7 and 12 years and still the mandible had the potential for growth, while in the present study adult sample was selected to exclude the growth effect. This result may be attributed to that CL.III subjects may had increased anterior facial height due to backward mandibular rotation or presence of dental and/or skeletal open bite.

❖ **Go-SBL**

This vertical distance correlates the point Gonion to the base of skull. The result revealed a close similarity of the mean value of this variable with a non-significant difference among the classes; this comes in agreement with **Baccetti et al. (1997)**. The results may be attributed to the nearly similar posterior facial height of the classes subjects, or nearly similar mandibular rotation.

## 4.3. The relationship between the anteroposterior positions of GF and the measured variables

The results indicated that there was weak direct significant correlation between the sagittal position of glenoid fossa (T-Fs') and ANB angle, and non-significant correlation between T-Fs' and T-Ar' and all measured variables. **Droel and Isaacson (1972)** found that the sagittal sella-glenoid fossa distance showed moderate direct highly significant correlation to ANB angle.

## 4.4. The position of GF in different vertical relationships

### *4.4.1. Angular measurement*

❖ **FS-SBL angle**

The results indicated that the mean value of this angle was higher in high angle than low and normal angle with a very highly significant difference, this difference may be attributed to the types of mandibular rotation in these groups as in high angle group the type of mandibular rotation is backward while it is forward in low angle.

### *4.4.2. Linear measurements*

1. **Sagittal measurements**

❖ **T-Fs' and T-Ar'**

The results revealed close mean values of these variables in different groups with a non-significant difference; this agrees with **Baccetti et al.** (**1997**).

This result may be attributed to types of mandibular rotations in which the center of rotation in the condyles does not affect Glenoid Fossa position in Antero-posterior plane.

**2.Vertical measurements**

1. **Fs-Fs' and Ar-Ar'**

The results indicated that the mean values of Fs-Fs' were significantly higher in low angle group than normal and high angles groups. This means that the position of the fossa summit relative to the basicranial structures was more inferior in low angle subjects when compared with subjects with normal or high angle vertical relationships. This comes in agreement with **Droel and Isaacson (1972)**. The possible explanation for these results may be attributed to differences in the upper and lower posterior facial height measurements.

The variations in the position of point Articulare in relation to the basicranial structures were approximately in the same direction as the variations in the position of point Fs. However, the position of point Articulare (Ar-Ar') showed significant differences only between normal and high angle subjects and between low and high angle subjects. This could be due to the fact that point Ar does not belong to the temporal bone as it is constructed at the intersection between the inferior surface of the cranial base and the posterior surfaces of the mandibular condyles (**Riolo et al., 1974**).

2. **Fs-FOP**

The results indicated that the mean value of this variable was highly significantly higher in low angle group than normal angle group. That means the distance from the fossa summit to the functional occlusal plane was larger in low angle group as in this group the occlusal plane tipped downward posteriorly following the forward mandibular rotation.

3. **Me-SBL and Go-SBL**

The results indicated that the mean value of Go-SBL was significantly higher in low angle group than normal and high angles groups while the mean value of Me-SBL was significantly higher in high angle group than normal and low angles groups. That means the distance from the Gonion to the SBL was larger in low angle group in comparison with high and normal angle groups and the distance from the Menton to the SBL was larger in high angle group in comparison with low and normal angle groups. This can be attributed to the type of mandibular rotation, as explained above, and the differences in the anterior and posterior facial height measurements.

## 4.5. The relationship between the vertical positions of GF and the measured variables

The results indicated that there was indirect weak to moderate very highly significant correlation between the Ar-Ar', Fs-Fs' and MP-SN angle, this agreed with those of **Droel and Isaacson** (**1972**), and direct moderate very highly significant correlation between vertical position of GF (Fs-Fs' and Ar-Ar')and Go-SBL**,** and there is indirect weak very highly significant correlation between vertical position of GF (Fs-Fs' and Ar-Ar') and FS-SBL angle; this indicated that the vertical position of glenoid fossa is influenced by mandibular rotation and the cant of the occlusal plane and this agreed with **Al-Mulla (2009)**, while there is non-significant correlation between Fs-Fs' and Me-SBL,Fs-FOP, and T-Fs'. The results revealed direct weak highly significant correlation between Ar-Ar' and Me-SBL and Fs-FOP, while there is non-significant correlation between Ar-Ar' and sagittal position of GF (T-Fs' and T-Ar'), and direct moderate very highly significant correlation between Fs-Fs' and T-Ar'.

The above mentioned correlations can be explained by two points:

1. Point Fs is a more consequent indicator for G.F vertical position than point Ar.
2. Strong relationship exists between G.F vertical position and posterior facial height.

# CHAPTER FIVE

# 5. Conclusions and Suggestions

## 5.1. Conclusions

The present investigation identified some significant elements regarding glenoid fossa position in different sagittal and vertical facial types:

**1.** Class II skeletal relation is associated with a more posterior position of the glenoid fossa when compared to Class III skeletal relation regarding the Anteroposterior plane.

**2.** Subjects presenting with high angle vertical relationships show a more cranial position of the glenoid fossa in relation to the cranial base when compared to subjects with either normal or low angle vertical relationships regarding the vertical plane.

**3.** This study did not reveal a strong relationship between the glenoid fossa position and the functional occlusal plane in anteroposterior and vertical relationships.

## 5.2. Suggestions

1. Conducting a lateral cephalometric study to verify gender difference in glenoid fossa position .
2. Carrying out a three dimensional analysis of the glenoid fossa position in different skeletal patterns.
3. Conducting a lateral cephalometric study to evaluate the glenoid fossa position in CL.II associated with:
   - Mandibular retrusion only.
   - Maxillary protrusion only.
   - Combination.
4. Carrying out a lateral cephalometric study to evaluate the glenoid fossa position in CL.III associated with:
   - Mandibular protrusion only.
   - Maxillary retrusion only.
   - Combination.
5. Further study is needed to evaluate the glenoid fossa position in different skeletal patterns by using computerized tomography.
6. A comparative study to evaluate the validity of Fs-SBL angle and Fs-FOP with standardized anatomical landmarks.

# Appendix I:

***Case sheet prepared for this thesis: Position of glenoid fossa in different skeletal patterns***

*Patient name* …………………. *Age* …………………

*Gender* ………………… *Occupation*…………………..

*Address* ………………….. *Date* …………………..

*Telephone no* …………………..

**** Medical History:***

_______________________________________________

_______________________________________________

****Dental History:***

_______________________________________________

_______________________________________________

****Skeletal relationships:***

| ***Sagittal:*** | ***Vertical:*** |
|---|---|
| ***CL.I……….…*** | ***Normal angle…………..…*** |
| ***CLII……….…*** | ***High angle….……………*** |
| ***CL.III………..*** | ***Low angle ……………….*** |

**** Clinical Examination***

***1. Range of mandibular movement …….mm***

## 2. Palpation of masticatory muscles: *positive* *negative*

- ***Masseter*** .......... ……….
- ***Temporalis*** ........... ……….
- ***Medial pterygoid*** ………. ……….
- ***Lateral pterygoid*** ……..… ………..

## 3. Palpation of TMJ: *positive* *negative*

- ***TMJ sound*** ………. ……….
- ***TMJ locking*** ………. ……….
- ***TMJ luxation*** ………. ……….

## 5. Examination of dentition: *Yes* *No*

- ***Extracted teeth*** … …
- ***Occlusal alteration*** … …
- ***Orthodontic treatment*** … …
- ***No. of teeth:***

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |

***Researcher name*……………….. **

***Supervised by Professor Dr. Fakhri Abid Ali*** ***Sig*……………….. **

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# الخلاصة

موقع الحفرة الصدغية يؤدي دور مهم في تأسيس مختلف الانماط الهيكلية. اجري هذا البحث للتحقق من موقع الحفرة الصدغية في الاشخاص ذوي العلاقات الهيكلية المختلفة ، تحديد العلاقة بين موقع الحفرة الصدغية والانماط الهيكليهة {السهمية والعمودية } ولتقييم العلاقه بين موقع الحفرة الصدغية ومستوي الاطباق الوظيفي.

اجريت دراسة شعاعيه جانبية للرأس على عينة من ١٢٤ شخص تتراوح أعمارهم بين ١٨-٣٠ سنة. صنفت العينة حسب العلاقة الهيكلية السهمية باستخدام زاوية ا ن ب إلى ثلاثة مجاميع (الصنف الأول=٤٨، الصنف الثاني=٤١، الصنف الثالث =٣٥ شخص)، وحسب العلاقة الهيكلية العمودية باستخدام الزاوية بين المستوي س ن ومستوي الفك الاسفل إلى ثلاثة مجاميع (زاوية طبيعية =٦٧، زاوية كبيرة=٢٣، زاوية صغيرة =٣٤ شخص)، تألف التحليل ألشعاعي القياسي من كلا القياسين السهمي والعمودي لتحديد موقع الحفرة الصدغية وعلاقتها بالتراكيب الهيكلية المحيطة. تم التحديد من خلال قياس ثلاث زوايا و٧ قياسات خطية تم قياسها باستعمال برنامج حسابي رقمي خاص (أوتوكاد ٢٠٠٨).

اظهرت النتائج ان موقع الحفرة الصدغية يميل للخلف أكثر في الصنف الثاني عند مقارنته بالصنف الثالث بالنسبة للعلاقة السهمية، بينما في العلاقة العمودية كان موقع الحفرة الصدغية بالنسبة للتراكيب في قاعدة الجمجمة للاسفل في الأشخاص ذوي الزوايا الصغيرة عند مقارنته في الأشخاص ذوي الزوايا الطبيعية والكبيرة ، كما ان خط الاطباق الوظيفي لا يرتبط بصلة على موقع الحفرة الصدغية في المستويين الأفقي والعمودي .

نستنتج من ذلك أن الاشخاص ذوي العلاقة الهيكليه العمودية بزاوية كبيرة يكون لديهم موقع الحفرة الصدغية اقرب الى قاعدة الجمجمه مقارنة بالاشخاص ذوي العلاقة العمودية بزاوية طبيعية وزاوية صغيرة ولا توجد قيمة للمعلومات التشخيصية من مستوى الاطباق الوظيفي في علاقته بموقع الحفره الصدغيه.

# موقع الحفوة الصدغية في الانماط الهيكلية المختلفة وعلاقتهاا بمستوي الاطباق الوظيفي

اطروحة مقدمة إلى مجلس كلية طب الأسنان في جامعة بغداد وهي جزء من المتطلبات لنيل درجة الماجستير في علم تقويم الأسنان

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**ماجستير في تقويم الأسنان**

**ذو الحجة ١٤٣٠هـ　　　　كانون الاول ٢٠٠٩ م**

**بغداد – العراق**