MENSURATION OF THE SAGITTAL SOFT TISSUE OF THE NASOPHARYNX FROM THE LATERAL NECK RADIOGRAPH

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SYNOPSIS

Thickening of the roof and posterior wall of nasopharynx caused by tumours can be detected in the lateral radiograph of neck. Ho and Oon have measured the diameters of the roof and the upper posterior wall to aid in the assessment of any thickening.

We find that many problems concerning radiography and anatomy of the nasopharynx have to be resolved before measurement could be satisfactorily carried out. The authors have developed two techniques of measurement: (a) Diameters, and (b) Area. Under (a), four diameters are recommended for measurement, namely: "Roof", "FM" or upper posterior wall, "C1" and "C2". Our method of measurement of the area is an original one.

INTRODUCTION

The roof and posterior wall of the nasopharynx* can be outlined in the lateral radiograph, and any enlargement caused by a tumour can usually be detected. Ho[3] and Oon[6] have measured the sagittal diameters of the roof and the upper posterior wall to aid in the assessment of any abnormal thickening of these parts.

One of us (F.Y.K.) began quantitative studies of the sagittal soft tissue of the nasopharynx some years ago, but soon encountered many problems related to radiography and anatomy which had to be resolved before measurements could be satisfactorily carried out.

*To avoid repetition of terms, the word *roof* implies the roof of the nasopharynx, and the term *posterior wall* means the posterior wall of the nasopharynx, throughout this article. Likewise *C1* is used for the atlas, *C2* for the axis, and *C3*, *C4* and so on for the successive cervical vertebral bodies. The special terms proposed by us are also placed within inverted commas. The various sagittal diameters are likewise placed within inverted commas to avoid confusion with anatomical names. Thus, "Roof" means the sagittal diameter of the roof, "FM" the sagittal diameter of the upper posterior wall, and "C1", "C2" and "C3" the sagittal diameters of the posterior wall at the levels of C1, C2 and C3 respectively.

†It is assumed that the patient looks straight ahead. This is important, because any pronounced flexion or extension of head may cause a change in the size of the "Bay" and the thickness of the posterior wall in some individuals.

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PROBLEMS CONNECTED WITH RADIOGRAPHY

Choice of Radiographic Technique

The standard lateral film of the neck as advocated by many authorities[1,2,5] is in our experience satisfactory for purposes of measurement. The exposure is made with the patient upright,† lateral shoulder against the cassette, at a focal spot film distance of 180 cm., and the central ray at or just below the level of the angle of mandible. The advantages of this technique are that distortion is reduced to a minimum, and radiologists elsewhere can directly match their readings without any need of correction. Besides, a number of lateral radiographs of the neck taken for other conditions may be utilised for study of the nasopharynx.

One objection that may be raised to the above technique is that the median plane-lateral shoulder diameter depends on the width of each patient and therefore greater magnification is obtained in broader subjects. We have found from a small series of measurements that the median plane-lateral shoulder diameter of our patients vary from 17 to 23 cm., averaging 20 cm. It can be seen that any difference arising from varying sizes of patients is relatively small and for practical purposes may be ignored.

Distortion can be reduced by placing the cassette against the lateral cheek and neck[7], instead of against the shoulder. We have taken radiographs using both techniques on the same subject in a number of cases, and have found approximately 10% less distortion with the lateral cheek and neck technique; but the disadvantage of this technique is that the lower neck is not visualised and therefore this technique is not routinely employed.

Quality of Radiographs

A radiograph of adequate penetration and of true lateral projection is essential for satisfactory visualisation of the roof and posterior wall. These objectives are not easily attained. Firstly, the soft tissues and bones vary in consistency. Secondly, some degree of rotation may occur because of slight movement of the patient after positioning. Thirdly, there may be some asymmetry of the head and neck.

Rotation may occur in two planes, transverse and coronal. Transverse rotation may be detected when the rami of mandible do not coincide, and coronal rotation when the postero-inferior borders do not coincide. The degree of rotation may be slight, about a few mm.; moderate, around 10 mm.; and marked, around 20 mm. (Figs. 3, 6, 8, 9, 10).

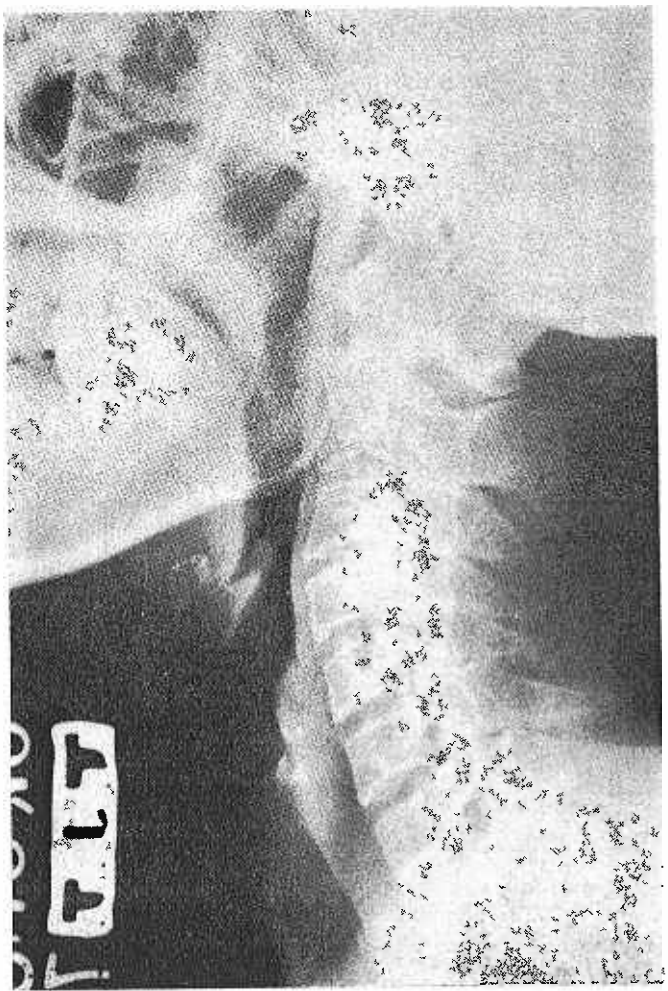

Fig. 1. L. M. G., female, 55. Lateral radiograph showing a "typical" or "ideal-looking" nasopharynx. The roof is of medium thickness and slightly concave. The "Bend" is slightly over 90 degrees. The "Bay" is medium. "FM vertical" is of medium length and slightly convex inferiorly. The tip of uvula is at the level of the middle of the body of the axis. The posterior walls of both maxillary sinuses, the posterior part of inferior turbinate, pterygoid bones and Eustachian fossa are well seen. The upper chamber of nasopharynx is funnel-shaped. This lateral radiograph of the neck is taken with the cassette against the lateral shoulder. Note the wide coverage of parts including the entire cervical spine, pharynx and larynx. This and the succeeding reproductions are lateral radiographs of the neck made on Chinese patients.

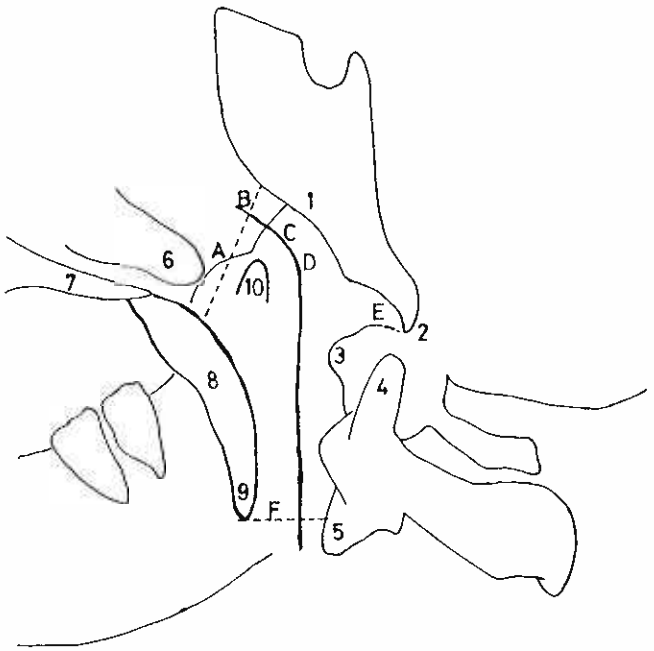

Fig. 2. Line drawing of Fig. 1 with key structures and landmarks identified. *A*. Inlet of nasopharynx represented by coronal plane of posterior choanae. *B*. Anterior limit of roof. *C*. Roof. *D*. "Bend." *E*. "Bay." *F*. Outlet of nasopharynx at level of tip of uvula. *1*. Basisphenoid. *2*. Basion. *3*. Anterior arch of atlas. *4*. Odontoid process of axis. *5*. Body of axis. *6*. Posterior part of inferior turbinate. *7*. Posterior part of hard palate. *8*. Body of soft palate. *9*. Tip of uvula. *10*. Eustachian fossa.

The greatest degree of rotation occurs along the transverse plane. Excessive rotation results in distortion of soft tissue shadows rendering them unsuitable for purposes of measurement (Fig. 10).

RADIOGRAPHIC ANATOMY

Introductory Remarks

Our experience shows that certain anatomical landmarks have to be established for defining the various sections of the sagittal soft tissue of the nasopharynx before measurements could be satisfactorily carried out. This in turn necessitates an understanding of the detailed radiological anatomy of the nasopharynx, made more complex by the existence of a large number of variations, hitherto undescribed. Such variations may change the location, or even obscure, certain essential landmarks. The lateral radiograph of a "typical" or "ideal-looking" nasopharynx (Figs. 1, 2) may be used for reference in our discussion below.

The Inlet and Outlet of the Nasopharynx

The lateral radiograph shows that the nasopharynx may be divided into two sections or chambers: a large rectangular or ovoid upper chamber lying above the level of the hard palate, and a tubular lower chamber. In the adult, the air filled upper chamber resembles the ventilating funnel of a ship or the bowl of a smoker's pipe,

while the lower chamber resembles the stem (Figs. 1, 5, 6, 9)[4]. In the young, the nasopharynx is somewhat tubular throughout and tends to be obliquely placed (Fig. 7).

The two posterior choanae form the inlet of the nasopharynx. We have found[4] that the approximate position of their coronal plane may be indicated by an upright line lying midway between the shadows of the posterior extremity of the inferior turbinate and the anterior border of the opening of the pharyngotympanic tube (Eustachian fossa) (Figs. 2, 12). If either the inferior turbinate or the Eustachian fossa or both are not defined, then the coronal plane may be placed about 9 mm. behind the posterior walls of the maxillary sinuses. If the latter do not coincide, then as a compromise, a point is chosen midway between the two posterior walls of the maxillae (Figs. 3, 8, 11b). The inclination of the posterior choana varies from vertical to about 35° posteriorly relative to a line extended backwards from the upper surface of the hard palate. We find that the average angle is approximately 16°[4]. Identification of the choanal plane is needed as it is taken to represent the anterior extremity of the roof were the latter not defined, to be used in our measurement of area.

The outlet of the nasopharynx is usually regarded as corresponding in level to the tip of the uvula with the soft palate in the relaxed position (Figs. 2, 12). This usually corresponds to the level of the body of C2, but at times may be higher and occasionally lower. A thin uvula may be difficult to identify; then the denser shadow of the lower end of the soft palate may be taken to represent its approximate position. Identification of the inferior limit of the nasopharynx is needed in our measurement of the area of the soft tissue (Fig. 13).

Fig. 3. O. S. K., male, 11. The roof is thick, ovoid and nodular. It presents a semi-oval bulge anteriorly. The "Bend" is moderately low and rather anterior in location because of the thick roof and upper posterior wall. The "Bay" is wide and therefore "FM vertical" is not as short as it otherwise would be. Note small and irregular shape of the upper chamber of the nasopharynx due to the massive nodular roof. There is moderate transverse rotation of mandible.

Fig. 4. L. A. K., female, 19. A very thick rectangular roof which ends almost perpendicularly on the basisphenoid. The "Bend" is at a right angle and moderately low and anterior in location. The "Bay" is medium and the lateral mass of the atlas is seen in front of the basion. "FM vertical" is straight and of medium length because of the moderately low position of C1. The tip of uvula is just above the level of C2. The upper chamber of the nasopharynx is small and deformed by the thick roof.

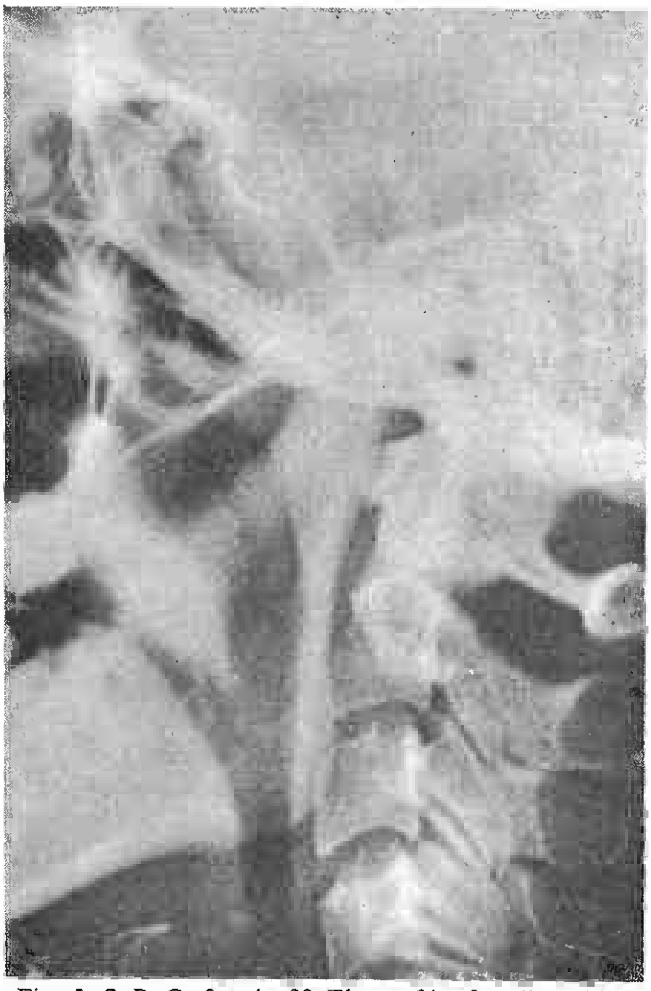

Fig. 5. S. B. C., female, 20. The roof is of medium thickness, ending as a wedge-shaped shadow anteriorly. The rather narrow "Bay" is due to the almost horizontal position of the basiocciput and high position of C1. The "Bend" is at the level of the anterior arch of C1 and moderately anteriorly located. Consequently "C1" is unduly large, and "FM vertical" is almost zero. "FM" is then measured between the basion and "Bend." The tip of the uvula is at the level of the lower body of C2. The upper chamber of nasopharynx is pipe-shaped.

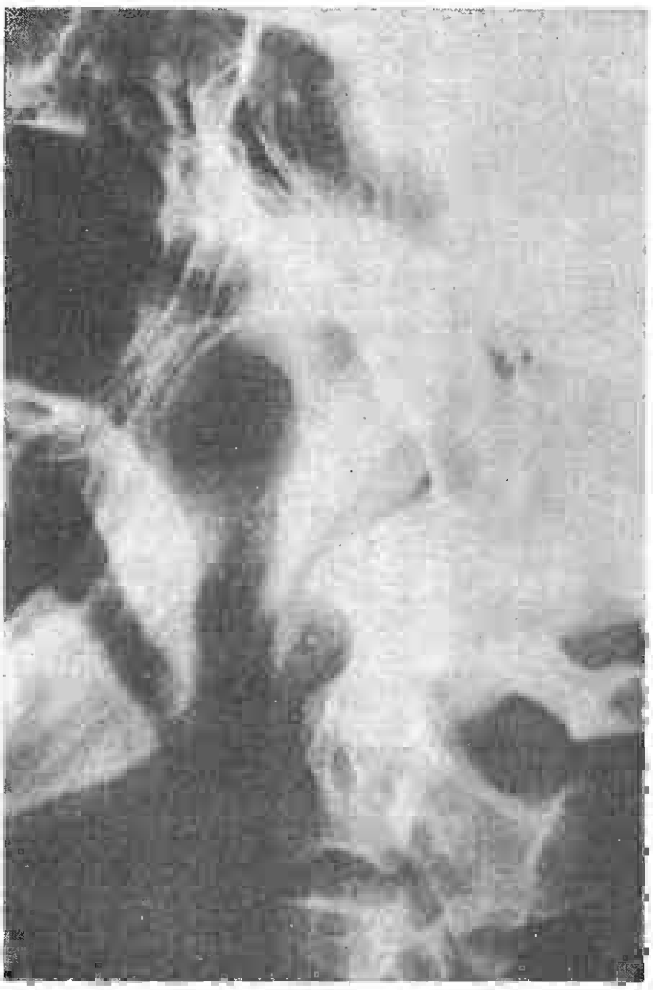

Fig. 6. K. A. H., male, 33. Moderately thick roof with double inferior concave outlines, the lower of which is probably the nasal septum. The anterior arch of atlas is moderately low and consequently "FM vertical" is of medium leng h and slightly convex inferiorly. The upper chamber of nasopharynx is somewhat oval in shape. There is slight transverse rotation of mandible.

SOME RADIOGRAPHIC LANDMARKS OF THE NASOPHARYNX NEEDED FOR MEASUREMENT

The roof is usually seen as a band of soft tissue in the upper part of the nasopharynx sloping downwards and backwards before making a turn downwards to become the posterior wall of nasopharynx. The turn is usually in the form of an angle or perhaps as a curve, which we term the "Bend" (Figs. 1, 2). The posterior wall runs somewhat vertically downwards before coming close to the middle of the anterior arch of C1. In its further course downwards the posterior wall is applied closely to the bodies of C2, C3 and so on.

The base of the skull overlying the roof is formed anteriorly by the basisphenoid and posteriorly by the basiocciput, both of which are fused together in the adult. The basiocciput tends to be concave inferiorly, and ends in the beak-shaped basion, which forms the anterior part of the foramen magnum. The basion is separated from the anterior arch of C1 by a small interval. Viewed as a whole, the inferior surface of the basisphenoid and basiocciput together with the upper surface of the anterior arch of C1 appear as a concavity looking forwards which we call the "Bay" (Fig. 2). The "Bay" is filled with soft tissue and is of considerable thickness which is limited anteriorly by the posterior wall. We call the horizontal diameter across the "Bay" measured from the basion to the anterior margin of the posterior wall "FM", meaning the diameter from the foramen magnum (Fig. 12). A somewhat comparable diameter is called by Ho the upper posterior wall of the nasopharynx. The stretch of the upper posterior wall from the "Bend" to the level of the middle of the anterior arch of C1 is called "FM vertical" because it lies approximately vertical to "FM" (Fig. 12). The significance of "FM vertical" will be apparent later on.

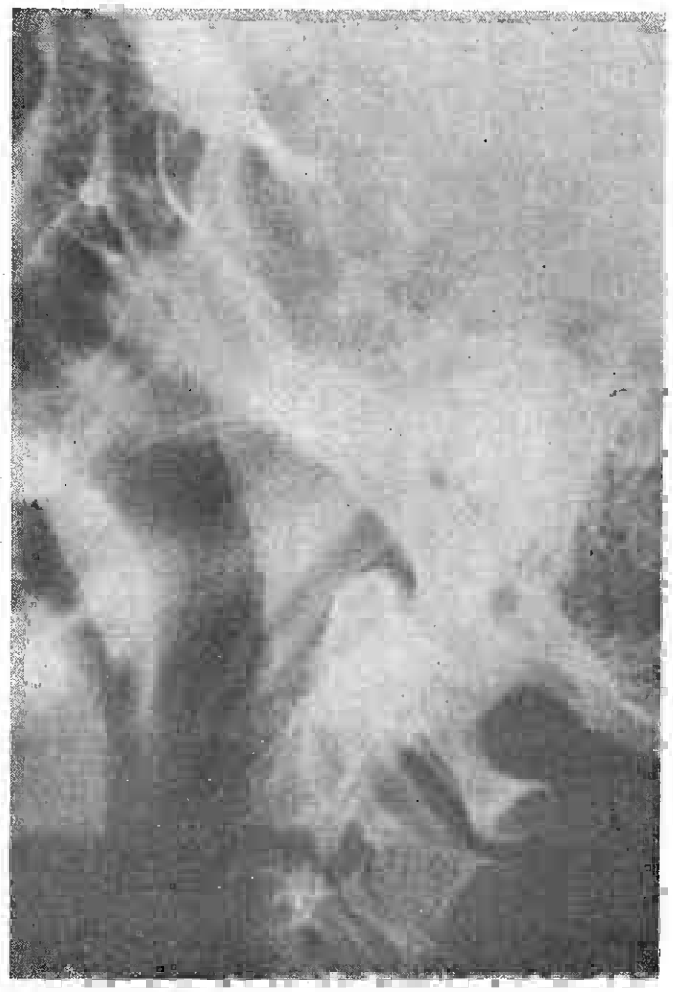

Fig. 7. L. S. K., female, 14. Rather thick triangular-shaped roof which descends fairly steeply at its middle to blend with the posterior wall of nasopharynx. The anterior arch of C1 is unusually high and lies above and in front of the basion. The "Bay" is consequently narrow and curved. The "Bend" is difficult to define. "C1" is rather large. The upper chamber of the nasopharynx is almost triangular in shape, and the entire air space of nasopharynx is like a slightly curved tube, slightly wider superiorly.

Fig. 8. C. C. T., male, 37. Rather thin concave roof hidden anteriorly by a malar arch. The basisphenoid is partly obscured by the malar arches. The "Bay" is extremely wide due to the steep basiocciput together with the rather low position of C1. The exact position of the "Bend" is difficult to define due to existence of a shallow concavity instead of an angle. The styloid process is seen in front of the basion. "FM vertical" is extremely long and straight. The anterior margin of the posterior wall appears to touch the anterior arch of C1. The tip of the uvula appears to lie above the body of C2. The posterior walls of the maxillae and posterior end of the inferior turbinate are well seen. The Eustachian fossa is a well defined ovoid shadow.

FACTORS INFLUENCING THE SIZE AND SHAPE OF THE NASOPHARYNX

It has been noted that the nasopharynx shows considerable variations in size and shape. This may be attributed to the great variability in size and shape of the bones and soft tissues.

The basiocciput varies not only in length, but also in its inclination downwards and backwards. The declivity is usually around 45 degrees (Figs. 4, 6), but occasionally it may descend almost vertically (Figs. 3, 8), and on the other extreme it may be almost horizontal (Fig. 5). The anterior arch of C1, which is usually a few mm. below and in front of the basion is also liable to variation in its level. Occasionally it may be slightly higher than the basion (Figs. 5, 7), and on the other extreme it may be several mm. below the basion (Fig. 8).* It can be seen that a wide "Bay" will result from a steep basiocciput coupled with a low position of the anterior arch of C1 (Fig. 8), and conversely a narrow "Bay" will be found when the basiocciput is almost horizontal and the anterior arch of C1 high (Fig. 5). It can also be appreciated that "FM vertical" will be long when the "Bay" is wide (Fig. 8) and conversely it will be short or zero when the "Bay" is narrow (Figs. 5, 7).

The position of the "Bend" is dependent on the thickness and type of roof. The "Bend" will be low in thick roofs and may lie at the level of the anterior arch of C1; "FM vertical" will then be short or even zero in value (Fig. 5). With marked thinning

*An excessively high anterior arch of C1, as seen in the relatively rare conditions of platybasia and basilar impression, would raise C1 to the level of the roof. This would disturb the usual relationship making it impossible to measure "C1" and "FM".

of the roof, the "Bend" will be high up and "FM vertical" will correspondingly increase in length (Fig. 8).

VARIATIONS OF THE ROOF AND POSTERIOR WALL OF NASOPHARYNX AND FACTORS INFLUENCING THEIR VISUALISATION

(a) **Roof**

No other section of the soft tissue shows so much variation in size and shape in relation to age as the roof. In childhood, the roof is thick and nodular in outline (Figs. 3, 4). In young adults, the roof gradually decreases in size and usually appears as a broad strip of tissue, and the inferior border may be convex, straight or slightly concave (Fig. 6). With increasing age, the roof gradually becomes thinner and is usually concave (Fig. 1). It is also increasingly difficult to visualise due to atrophic change and to overlapping by the malar arches and temporo-mandibular joints. In fact, it is the exception rather than the rule for the roof to be visualised in the elderly. At times, only a short posterior section of roof may be seen behind a malar arch or through a temporo-mandibular joint (Figs. 8, 9).

In most instances, the anterior end of the roof is lost sight of after crossing the shadows of the lateral pterygoids because of overlapping by many structures. The coronal plane of the posterior choanae can then be used to demarcate the anterior limit of the roof (Figs. 2, 12).

A thick roof, usually of the nodular type of the young, can be traced forwards to end over the basisphenoid, either as a wedge-shaped shadow, or perpendicularly, or as a projecting ovoid shadow (Figs. 3-5).

At times, the roof soon slopes fairly steeply downwards from its anterior portion. Such roofs are often thick and wedge-shaped, blending with the posterior wall as a gentle curve or continuing downwards almost as a straight line.

The anterior portions of some roofs appear to curve downwards and slightly forwards after crossing the pterygoids. This curved shadow is most likely caused by the nasal septum in the majority of cases (Fig. 6).

Fig. 9. O. S. T., female, 39. The roof, in spite of being moderately thick, is still overlapped by a malar arch anteriorly. A temporo-mandibular joint serves as a "window" for a short section of posterior roof to be seen. The "Bay" is medium. The "Bend" is at an obtuse angle although somewhat curved. "FM vertical" is of medium length and slightly concave. There is moderate transverse rotation of mandible.

Fig. 10. W. S. K., male, 61. There is marked transverse and coronal rotation of mandible resulting in a "garbled" appearance of the nasopharynx. The roof is not seen.

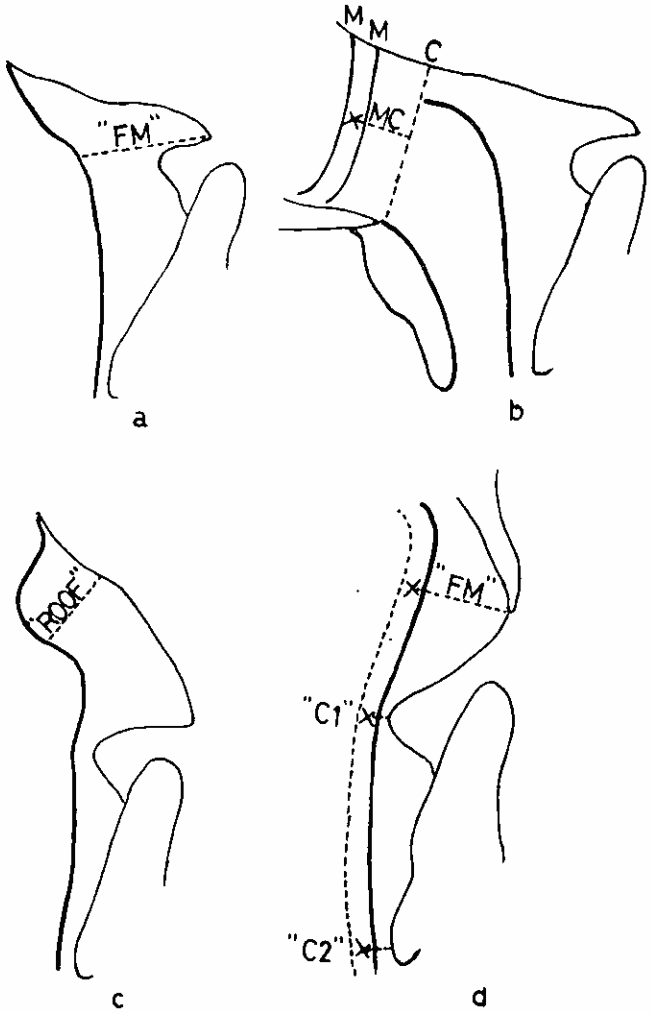

Fig. 11. *a*. Showing method of measuring "FM" between basion and "Bend" when "FM vertical" is zero. *b*. The cross is midway between the two widely separate posterior walls of maxillae (compromised method of locating the coronal plane of posterior choanae). MC is 9 mm. long. *c*. Method of measuring the "Roof" when the roof is convex. *d*. Showing method of obtaining compromised values of "FM", "C1" and "C2" when the posterior wall shows double outlines. The crosses lie midway between the two outlines.

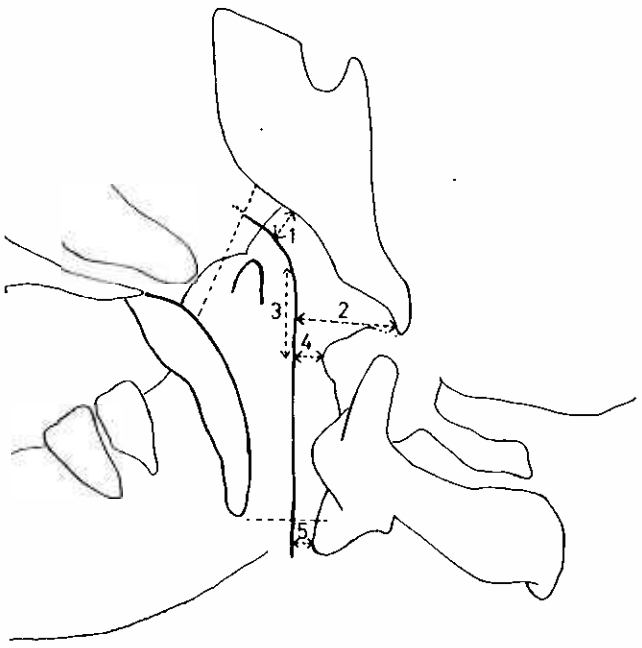

Fig. 12. Diagram showing the various sagittal diameters. *1*. "Roof." *2*. "FM." *3*. "FM vertical." *4*. "C1." *5*. "C2."

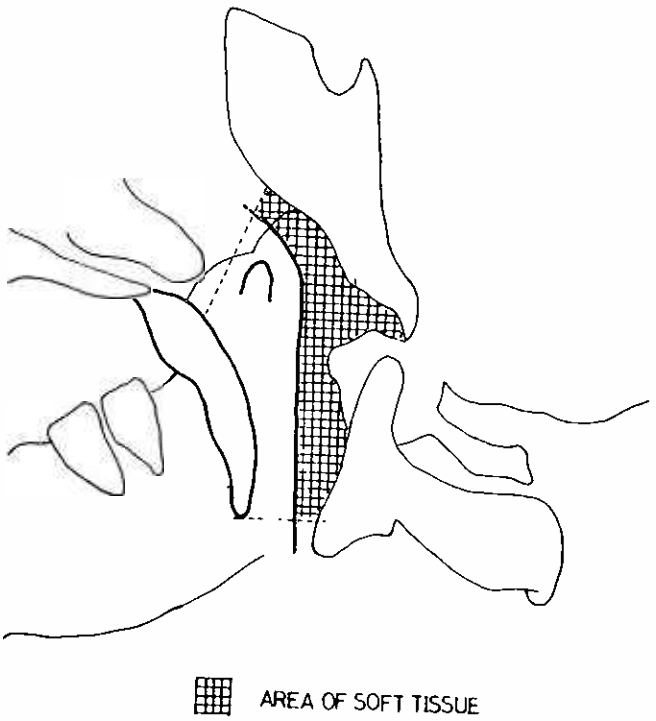

Fig. 13. The hatched area represents the total area of the sagittal soft tissue of the nasopharynx from inlet to outlet.

The rectangular or ovoid shapes of the air filled shadow of the upper chamber of the nasopharynx have been mentioned (Figs. 1, 5, 6, 9). It can be appreciated that the upper chamber would not only be diminished in size but also assume irregular forms in the presence of large nodular or wedge-shaped roofs (Fig. 3, 4).

(b) The "Bend"

The "Bend" is usually seen in the form of an angle, ranging from a right angle to an obtuse angle. In extreme cases, the angle may be replaced by a curve to an almost straight line, thus rendering identification of the "Bend" difficult if not impossible (Figs. 7, 8). The level of the "Bend" is influenced by the type of roof; it is high in thin roofs, and low in thick roofs. It may lie relatively far forwards in nodular or wedge-shaped roofs, or in association with a high position of the anterior arch of C1 (Figs. 3-5).

(c) The Posterior Wall of Nasopharynx

This begins at the "Bend" and runs almost vertically downwards before coming close to the middle of the anterior arch of C1. This section is called "FM vertical" and varies greatly in length, as already explained. "FM vertical" is usually straight, but may be slightly convex or more often slightly concave. Were the "Bend" to be located at the same level of the middle of the anterior arch of C1, then "FM vertical" would be of zero value. A

shallow bay of soft tissue is present between C1 and C2 which is utilised in our measurement of area (Fig. 13).

The posterior wall may at times appear to possess two anterior outlines, caused by transverse rotation or asymmetry of structures of head and neck Pathological thickening of soft tissue due to congestion, abscess or tumour may also cause doubling of outline. The separation of shadows varies from 1 to 3 mm. or more, and usually the anterior shadow is faint.

(d) The Basisphenoid

The basisphenoid usually appears as a slightly convex shadow in the lateral radiograph. Identification of the inferior border may at times be difficult because of the curved surface of bone, which may result in double shadows. The inferior borders of the sphenoidal sinuses and of the floors of the middle cranial fossae may also cause confusion. Because of many overlapping shadows, a radiograph of adequate penetration is essential for satisfactory visualisation of the basisphenoid.

(e) The Basiocciput

This bone forms the upper part of the "Bay" and its basion, a beak-shaped process, forms the most posterior part of the "Bay" The basion is the posterior point used in the measurement of "FM" and its identification is important because it is liable to be overlapped by many structures including the occipital condyles, styloid sheaths and processes, lateral masses of C1 and mastoid processes, which may lie in front of it. Again, a radiograph of adequate penetration is essential for showing up the basion (Figs. 4, 7).

(f) The Anterior Arch of C1

The anterior arch of C1 is seen in cross-section as an ovoid shadow in the lateral radiograph. The mid-point of the anterior border of the arch is the posterior point used in the measurement of the diameter "C1" (Fig. 12). The lateral mass of C1 may at times project over the anterior arch, and may cause confusion.

(g) The Body of C2

The posterior wall on its way down lies nearest to the lower part of the body of C2. This level is chosen for measurement of the diameter "C2" (Fig. 12).

PRACTICAL APPLICATIONS

We have already discussed the radiographic technique of the lateral neck, and the radiographic anatomy of the nasopharynx and the identification of certain essential landmarks Considerable attention is paid to anatomical variations which may change the position or even obscure certain landmarks. It is important to have a clear grasp of the foregoing before measurements could be satisfactorily made.

Ho[3] was the first to propose the measurement of two sagittal diameters of the soft tissue of the nasopharynx in the lateral radiograph, namely, the roof and upper posterior wall. We feel that there is a place for two additional diameters, namely, at the levels of C1 and C2, making a total of four: they are "Roof", "FM", "C1" and "C2". In addition, we are also introducing an original method of measurement of the area of the soft tissue which we feel may be of use in the assessment of enlargement caused by tumours. Our techniques of measurement of diameters and area are presented below.

A. MEASUREMENT OF THE SAGITTAL DIAMETERS OF THE SOFT TISSUE OF THE NASOPHARYNX

1. "Roof"

Ho[3] measures the roof "at the point of attachment of the posterior border of the lateral pterygoid to the base of skull". Oon[6] appears to follow Ho, and his illustration shows an oblique line running downwards and anteriorly from the base of the skull to cut across the upper limit of the nasopharynx. It appears that this diameter tends to be somewhat oblique.

We have mentioned that the roof may be hidden by the malar arches and the temporo-mandibular joints. Oon also made mention of difficulty caused by the malar arches The roof may therefore be divided into two categories: one in which the inferior border is clearly seen and the other in which it is obscured partially or totally by other structures.

(a) *Roofs with well Defined Inferior Border*

Such roofs are either relatively thick, or the malar arches are high in location (Figs. 1-7). The inferior border of such roofs may be convex, flat or concave The posterior part of the middle third of the roof is usually selected for measurement of the sagittal diameter. A line perpendicular to the basisphenoid is dropped to the inferior border of the roof, at the point of greatest convexity for convex roofs (Figs. 11, 12), and the point of greatest concavity for concave roofs. We feel that satisfactory average values are obtained in all types of roofs by this technique except perhaps for the very thick nodular roofs of the young. As the latter show great variations in size and shape, we feel that there is no necessity for a more rigid criterion of measurement.

(b) *Roofs Obscured by Malar Arches and Temporo-Mandibular Joints*

This usually occurs in the thin roofs of the elderly, and sometimes in roofs associated with low malar arches (Figs. 8, 9). It is, however, more often for the malar arches to obscure the anterior portions of the roofs. In such instances, the posterior portions of the roofs are still visualised, and we can still employ our method of measurement as described above. In the extreme case when the roof is entirely obscured, we then try to locate the "Bend" which might still be visible, and measure the diameter of the roof at this point. Were the "Bend" also obscured, then the diameter at the point of the highest part of the visible posterior wall is measured. The diameters obtained by the last two manoeuvres may be about 1 to 2 mm. greater than that obtained at the middle of the roof, but may be accepted as being near the actual value. Sometimes the radiolucent shadow cast by the anterior portion of one temporo-mandibular joint serves as a "window" through which a short section of the roof or "Bend" may be seen, and again measurements can be effected (Fig. 9). In spite of these manoeuvres, measurement may have to be abandoned in a few cases with excessive distortion of shadows (Fig. 10).

2. **"FM" or Upper Posterior Wall of the Nasopharynx**

The points used by Ho are "at the apex of the angle formed by the anterior border of the occipital condyle and the basiocciput . . . ". Oon recommends measuring the plane connecting the posterior edge of the bony palate to the anterior lip of the foramen magnum. It can be seen that were the hard palate to be rather low in position, the diameter resulting in this method would be even more oblique and unduly long.

In our method, the basion is first identified, and "FM vertical" noted for its characteristics, that is, whether straight, convex or concave. A horizontal line is then drawn from the basion to "FM vertical" if the latter is straight, or to the most convex point if convex, and to the most concave point if concave. This line represents our diameter "FM", which is almost similar to the upper posterior wall diameter of Ho and of Oon, although perhaps slightly shorter. Were "FM vertical" to be of zero value, then "FM" is the diameter between the basion and "Bend". At times, the upper posterior wall may be double in outline, in which case a point is chosen midway between the two lines and to represent the anterior limit of "FM", and a compromised value obtained (Figs. 11a, d; 12). Care must be taken to identify the basion from other overlapping shadows in front of it; otherwise an error of 1-3 mm. may result.

3. **"C1"**

The diameter at the level of the most anterior part of the anterior arch of C1 was not mentioned by Ho and by Oon. We feel that this diameter may be useful in the assessment of thickening, although it is liable to a moderate degree of variation in width. Measurement is made from the most anterior point of the anterior arch of C1, usually at its middle. A horizontal line is then drawn to touch the anterior margin of the posterior wall; we call this diameter "C1". Occasionally, the posterior wall appears to touch the anterior margin of the arch, thus reducing the diameter to zero (Fig. 8). Sometimes the posterior wall is double, in which case a compromised value may be obtained (Figs. 11d, 12).

4. **"C2"**

This diameter is taken at the level of the most prominent point of the body of C2, usually at its lower half. Occasionally the anterior wall is double, in which case a compromised value may be obtained (Figs. 11d, 12). Neither Ho nor Oon made mention of this diameter, but Oon has recorded the diameter at C3. We find that "C2" and "C3" have almost identical values.

B. MEASUREMENT OF THE AREA OF THE SAGITTAL SOFT TISSUE OF THE ROOF AND POSTERIOR WALL OF THE NASOPHARYNX

Measurement of the diameters of many organs of the body from the radiograph is commonly practised, but measurement of areas is less frequent. Examples of area measurement are the heart, kidney and pituitary fossa. We are not aware of any report on measurement of the area of the roof and posterior wall from the lateral radiograph.

The technique we employ is to trace the mucosal outline of the entire soft tissue of the nasopharynx from inlet to outlet on tracing paper. The bony outlines are next traced, namely, basisphenoid, basiocciput, anterior arch of atlas, and body of axis. Care must be taken not to include the lateral mass of atlas and transverse process of the axis were these to project forwards beyond the anterior arch of C1 and the body of C2 respectively (Fig. 13). The tracing paper is then pinned to a drawing board and the area measured with the aid of a planimeter. It is advisable to take the average obtained from three readings.

In case the anterior end of the roof is not seen, then the coronal plane of the posterior choanae may be used to represent the anterior limit of the roof. Were the greater part of the inferior border of the roof obscured by the malar arches, then the junction of the visualised posterior part of the roof with the malar arch is marked. A line is then drawn parallel to the base of the skull to cut the coronal plane of the posterior choanae. The rectangular strip thus mapped out may be taken to represent the roof. Similarly, the "Bend" or the highest part of the visualised posterior wall may be used as the most posterior point were the roof entirely obscured. Measurement, however, may have to be abandoned in cases showing excessive distortion of shadows.

GLOSSARY OF RADIOLOGICAL TERMS

Roof: The roof or pharyngeal tonsil is the soft tissue at the superior aspect or vault of nasopharynx. It contains much lymphoid tissue in the young. The nasal septum may be found as a prominent ridge along the median plane of the anterior part of the roof A specialised structure made up of folded mucosa and lymphoid tissue, called the pharyngeal bursa is found along the median plane of the posterior part of the roof. The roof is therefore a composite shadow of many structures lying along the same transverse plane.

Posterior Wall of Pharynx or Retropharyngeal Wall: This stretches from the basiocciput to the laryngopharynx. The portion belonging to the nasopharynx lies between the basiocciput to the outlet of the nasopharynx. Some writers use the term posterior wall of nasopharynx for the stretch of soft tissue lying between the basiocciput and the atlas.

"Bend": The anterior junction between the posterior part of the roof and the upper posterior wall of nasopharynx. It may be angulated and well defined or difficult to determine in curved or steeply descending roofs.

"Bay": An incomplete bony concavity formed superiorly by the basiocciput and inferiorly by the anterior arch of atlas, with a gap between them. The basion, which is the inferior end of the basiocciput, forms the most posterior portion of the "Bay".

"FM vertical": This is the anterior border of the upper posterior wall running from the "Bend" to the level of the middle of the anterior arch of atlas.

Sagittal Diameters of Soft Tissue

1. *"Roof":* A vertical diameter taken across the middle of the roof.
2. *"FM":* A horizontal diameter taken across the soft tissue within the "Bay", from the basion to the anterior surface of "FM vertical".
3. *"C1":* A horizontal diameter of the posterior wall taken at the most anterior point of the anterior arch of atlas.
4. *"C2":* A horizontal diameter of the posterior wall taken at the most anterior point of the body of the axis.

Area of Soft Tissue of Nasopharynx: The area of the entire strip of soft tissue comprising the roof and posterior wall, from the inlet to the outlet of the nasopharynx.

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