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THE SOFT TISSUE SIGN: A NEW PARAMETER IN THE DIAGNOSIS OF THE FRACTURES OF THE BASE OF THE SKULL

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The detection of a fracture of the base of the skull on a radiograph is at best difficult and may be impossible (du Boulay, 1965). Any addition to the diagnostic methods presently in use should, therefore, be welcome. The new 'soft tissue sign' is suggested, where an increase in the width of the posterior nasopharyngeal soft tissues is observed in a high proportion of patients with skull base fractures.

PATIENTS AND METHODS

Forty-five patients, clinically diagnosed as having a fractured base of skull, were studied. All were admitted to the Accident Unit of the Johannesburg Hospital during 1976 and the first half of 1977.

The *clinical criteria* for the diagnosis were one or more of the following signs (Mock, 1950): cerebrospinal fluid rhinorrhoea or otorrhoea, bleeding from one or both ears and haemotympanum.

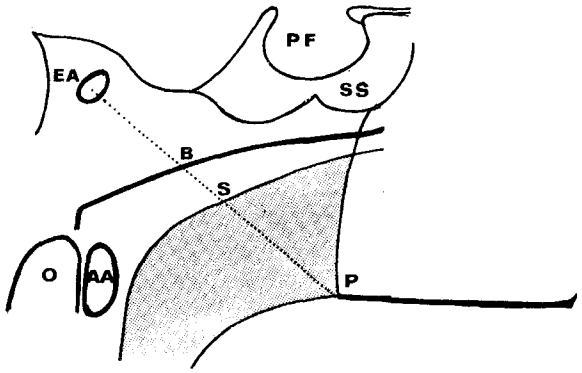

Fig. 1 – A diagramatic representation of the relevant portion of the lateral skull film. EA is the external auditory meatus, from which a line is drawn to P, the posterior end of the hard palate. The distance measured BS is from B, the skull base to S, the anterior margin of the soft tissue. PF is the pituitary fossa, SS the sphenoid sinus, O the odontoid process, and AA the anterior arch of the atlas. The shaded area is the posterior nasopharyngeal air space.

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The *lateral film of the skull* taken supine (brow-up) with a horizontal beam was used for the radiological measurement of the 45 patients (38 adults and seven adolescents) with basal skull fractures. These data were compared with 80 normal (60 adult and 20 adolescent) skull films.

The soft tissue thickness of the posterior nasopharynx was assessed (Figs. 1, 2, 3) along a line drawn from the middle of the external auditory meatus, EA to the posterior end of the hard palate, P. The distance measured, BS, was from B, the base of the skull, to S, the anterior margin of the soft tissue.

The effect of *flexion and extension* of the head on the width of the soft tissue was studied in several of the patients. Such postural change caused insignificant alteration in the measurement BS.

Correlation was sought between the soft tissue thickness and the *severity of the head injury* on one hand and on the other hand the previously used criteria of *sphenoid or ethmoid fluid levels* (du Boulay, 1965; Walker *et al.*, 1969; Taveras and Wood, 1976) and *intracranial air* (du Boulay, 1965).

RESULTS

The measurements of the soft tissue thickness (BS) are presented separately for adults and adolescents (Table 1). This distinction was drawn in case of the presence of adenoid tissue in adolescents might have caused false positive results. In fact this occurred in only one out of 20 normal adolescent patients.

From Table 1 it can be seen that the *average* soft tissue thickness in patients with a fractured base of skull was nearly twice that measured in normal patients and that there was little difference between adults and adolescents. The results have been analysed and found to be statistically highly significant ($P < 0.01$).

Of the 45 patients with a fractured base of skull, only 14 showed the presence of a sphenoid or ethmoid fluid level. In no patient was intracranial air demonstrated.

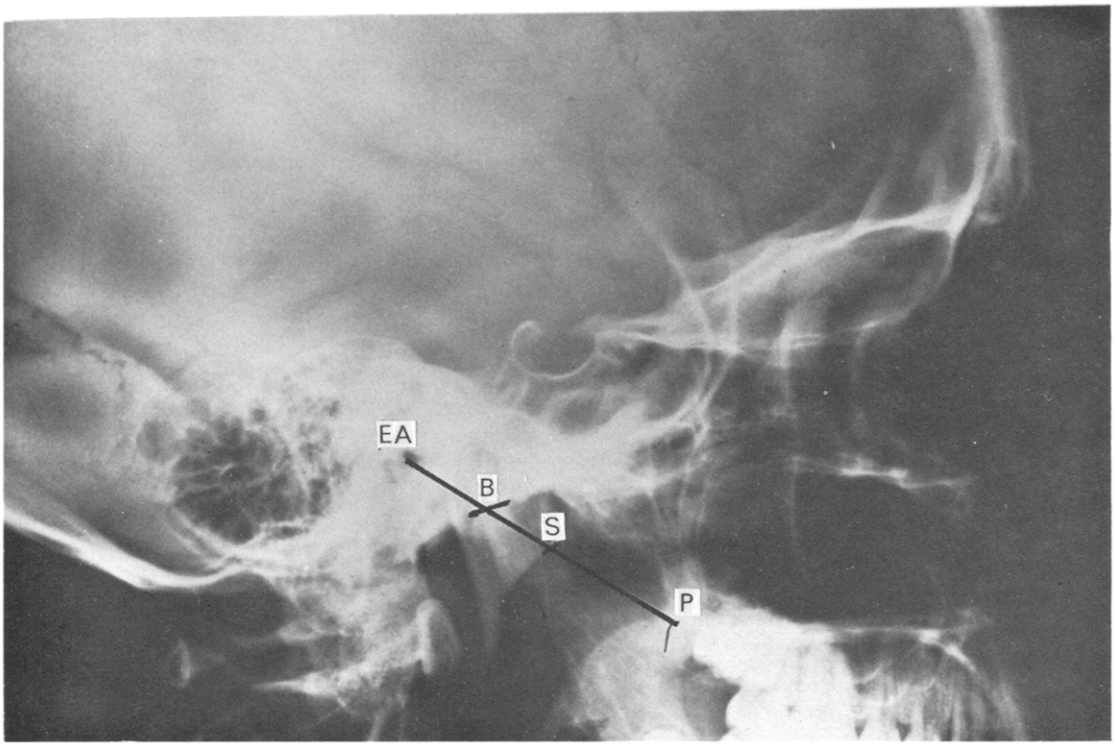

Fig. 2 – Supine lateral skull radiograph of a normal adolescent patient, showing a soft tissue thickness (BS) of 12 mm, as measured on the original film. The external auditory meatus (EA) and posterior end of the hard palate (P) are easily identified.

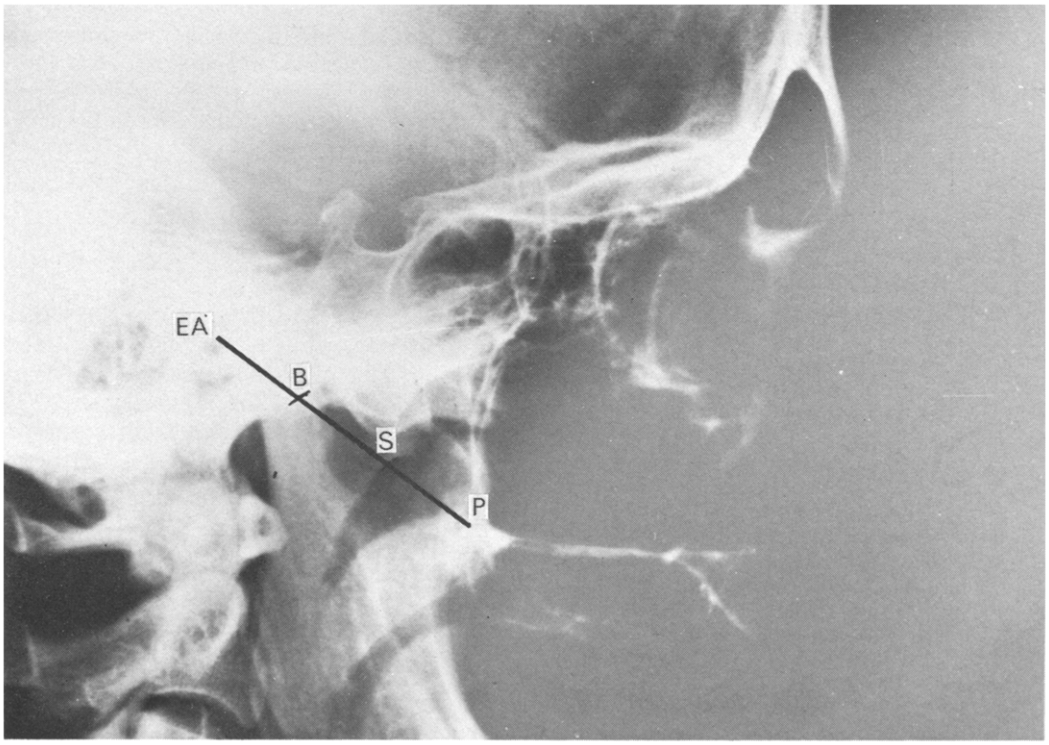

Fig. 3 – Supine lateral skull radiograph of an adult patient with a clinically diagnosed fracture of the base of the skull. The soft tissue thickness (BS) measured 19 mm.

Table 1

Category	*Age group*	*No.*	*Average thickness BS (mm)*	*Range of thickness (mm)*	*Sphenoid ethmoid fluid levels no. of patients*
Fracture of base of skull	Adults	38	20.04	13–30	13
	Adolescents	7	19.8	16–26	1
	Overall	45	20.01	13–30	14
Normal	Adults	60	10.03	5–15	0
	Adolescents	20	10.68	5–16	0
	Overall	80	10.19	5–15	0

The soft tissue thickness was greater in the patients in whom the injury was clinically more serious e.g. one patient with a measurement of 25 mm was in coma for 14 days; another with brain tissue discharging from the nose had a soft tissue thickness of 27 mm; 27 mm was recorded in a patient with a bilateral haemotympanum.

In those patients radiographed serially, the soft tissue swelling was observed to be maximal from 24 to 48 h and thereafter to decrease rapidly.

The technique could not be applied where an endotracheal tube or oropharyngeal airway was in position. This was because the posterior nasopharyngeal air space was obliterated by upward displacement of the soft palate.

DISCUSSION

In a busy accident unit, where speed and accuracy of diagnosis is essential, there is distinct benefit in a simple and more precise radiological method for detecting fractures of the base of the skull. In addition, the advocated measurement can be carried out on the most easily obtained view (viz. the lateral) of the skull. Sphenoid and ethmoid fluid levels are also visible on the lateral, brow-up film, (du Boulay, 1965) but the other view advocated, i.e. the basal and the use of tomography (Taveras and Wood, 1976) are far more time-consuming. Direct evidence of a fractured base may be obtained on the basal view and best by tomography, but in an emergency half an hour for tomography may not be available.

The advocated technique of soft tissue measurement admittedly adds only indirect evidence of fractured base of skull. Nevertheless, it is a decided improvement on the previously used indirect parameters. In this series the number of fractures showing soft tissue swelling was more than double the fractures presenting with sphenoid and ethmoid fluid levels. No patient showed intracranial air.

The reason for the soft tissue swelling is almost certainly leakage of blood, and/or cerebrospinal fluid into the submucosal connective tissue of the posterior nasopharynx, or to oedema formation in this plane. It is, therefore, logical that more extensive fractures are likely to be associated with greater swelling, as found in this series.

In addition to the visible swelling, the basal fracture undoubtedly causes an approximately equal sized haematoma on the *inside* of the skull. Resultant pressure on and displacement of the base of the brain and the brain-stem may be life-threatening.

It is proposed that a measurement of 16 mm be used as the lower limit of soft tissue thickness for suspecting a fractured base of skull (15 mm is the upper limit in *normal* adult skulls). Let us refer to the new parameter as the 'soft tissue sign'. Then, 39 out of the series of 45 patients would have a positive soft tissue sign. Of all of the normal patients, only one, an adolescent, had a 16 mm thick soft tissue pad and adenoids were clearly visible. In the whole series of normals and abnormals, one false-positive sign was present, therefore, and six false-negatives (in whom the soft tissue thickness was between 13 and 15 mm).

Some of the false-negative results obtained may have been due to the elapsed time after injury, as the soft tissue swelling decreases after 48 h. Several of the injured patients were referred from distant hospitals – often several days after injury.

Another possible cause of false-negative results is the portion of the skull base involved in the fracture. Many base fractures involve the middle cranial fossa (Mock, 1950) and, therefore, the basi-sphenoid or basi-occiput. Such fractures would produce maximal effect on the closely related soft tissues of the posterior nasopharynx. Conversely, fractures of the anterior cranial fossa which are some distance away, should produce less swelling.

The differential diagnosis of soft tissue swelling at the base of the skull includes the adenoidal pad in children (the soft tissue sign should, therefore, be interpreted with reserve in adolescents), prevertebral abscess or tumour (Zornoza *et al.*, 1977) and injuries

to the upper cervical spine (von Torklus and Gehle, 1972; Kerschner *et al.*, 1977).

The soft tissue swelling is easy to detect and measure: the swelling focuses the radiologist's attention on the area involved, thus lessening the likelihood of overlooking a potentially serious fracture. Furthermore, it would seem sensible to consider embarking on computerised axial tomography or cerebral angiography if the 'soft tissue sign' is positive in a patient with a history of recent head injury.

CONCLUSION

Increased width of the posterior nasopharygeal soft tissue is suggested as a worthwhile supplement to the existing indirect radiological evidence of skull base fractures.

The advantages of this new technique are that it is performed quickly and easily on the readily obtainable lateral skull film. The fixed points necessary (external auditory meatus and posterior end of the hard plate) are always visible on the radiograph. The detection rate (39 out of 45) is considerably greater than by the conventional method of demonstrating ethmoid or sphenoid fluid levels (14 out of 45) or intracranial air (none out of 45).

SUMMARY

A retrospective study has been made on the brow-up lateral skull radiographs of 45 patients with clinically diagnosed fractures of the base of the skull and of 80 normal patients. The thickness of the posterior nasopharyngeal soft tissues has been found far more reliable indirect evidence of fractured base of the skull than the previously used parameters (sphenoid and ethmoid fluid levels, intracranial air). The measurement is easily and quickly performed and demands no additional views of the skull. Care should be taken in the interpretation of the sign in adolescents where adenoids are large, where injuries to the upper cervical spine are present, or where more than 48 h has elapsed since injury.

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