

2.5.4 Reflexive and Habitual Patterns of Behaviour

Barrett and Hanson (1978), having a specific interest in this field of study, reiterate the fact that not all of the swallowing act is reflexive. They point to the fact that the end organs responsible for firing off the swallowing reflex (a complex all-or-nothing reflex response triggered by peripheral nerve stimulation) are located in the pharyngeal region. Thus, a bolus reaches this region, and triggers the reflex only at the conclusion of the oral or first phase of deglutition. They stress that there is general agreement that the oral phase is not bound in the reflex. It is voluntary, and although it is usually unconscious, it may easily be called up to consciousness. It is usually performed in a habitual manner - habits thus being of a normal nature. There are normal and abnormal habits, or rather, useful and useless habits. In orthodontics we usually give "habits" a negative connotation, e.g., thumb sucking, nail biting, etc. However, these authors remind us that the oral phase of swallowing is carried out at a subconscious level in a useful manner, without untoward effects, i.e. habitually - just as we carry out the gross and fine motor skills used in everyday living, e.g., driving a car. We have the choice, though, of bringing our consciousness to this activity or not. This is the same for swallowing, it would seem, although this process has the added advantage of continuing while consciousness is removed, under reflex control, e.g., when sleeping. With this concept of habitual behaviour of the oral phase of swallowing, modification, as witnessed by Moyers' (1973) account, becomes a more feasible proposition.

On this point, Truesdell and Truesdell (1937) observed, "only the first stage of deglutition is under the control of the will of the individual, and it is usually unconscious for it has been made a 'habit' as have so many of the routine acts of living to allow us time to think of and perform other acts that require our conscious attention. However, the first stage can easily be brought

back to consciousness by the person, and modifications can be made as desired."

Barrett and Hanson (1978) have gone one step further to point out that even if this action were reflex, it could still be changed. They point to the fact that it is only necessary to alter one element of the reflex arc to change the response. For example, they use the pupillary reaction to light and the contraction of blood vessels as being previously thought of, on the whole, as highly inaccessible reflexes. Yet, using modern feedback procedures, or under hypnosis (as well as meditation techniques), they become accessible to alteration.

Finally, on a more esoteric note, Scott (1969) presented us with another aspect of neural organisation in general, and the tongue in particular, in relation to function. He stressed that the fundamental regulating mechanism of all oral activities resides in the brain stem, which he termed the "computer system" coordinating all oral activities.

Scott said that it is the neural integrating system that creates and regulates the various functional components of the oral cavity. Also, it is the neural component that determines the contribution of the tongue to such various functions as the tactile testing of food, swallowing, mastication, and oral hygiene. Neural connections not only determine the patterns of muscle activity, but probably also their growth, which, in turn, influences the development and growth of various parts of the craniofacial skeleton. "It is the elaboration of neural patterns and connections which imposes function upon structure within the oral cavity. Without it, no matrix can be functional."

2.6 Variability of Normal Swallowing with Maturation

It is generally agreed by orthodontists, otorhinolaryngologists, speech pathologists and others (Rix, Ballard, Tulley, Gwynne-Evans, Straub, Moyers, Ricketts, Hanson, Barrett, etc.) that there are distinct changes in swallowing patterns from birth to adulthood. Indeed as mentioned previously (Dellow, 1976), studies have shown swallowing behaviour in the foetus. It is believed that the performance of swallowing amniotic fluid can be regarded as training for the crucial act of suckling in the post-natal period. In fact, the daily volume of amniotic fluid swallowed shortly before birth matches that of the mother's milk ingested just after birth.

The distinct changes are divided into three stages: the infantile swallow (suckling), the transitional swallow, and the mature swallow (Cole and Cole, 1980). According to Rampp and Pannbacker (1979) when an infant swallows, there must be strong lip action to grasp the nipple, and the tongue tip is placed under the nipple. The jaws are held apart and the milk is tunnelled down the tongue into the pharynx. As the infant becomes older, a semi-solid diet is instituted and the swallowing pattern changes. After solids predominate in the diet, lip activity is reduced considerably and the jaws are brought together by contraction of the muscles of mastication with the tongue tip behind the maxillary central incisors. Transition swallowing periods from infant to adult stages begin very early in life and last a long time. A large number of young children have an infantile swallowing pattern that is part of a transitional stage that includes a tongue thrust swallow. These authors claim that fifty per cent of 6-7 year olds approximate an adult swallowing pattern. The other fifty per cent continue to show various transition stages throughout their pre-pubescent years. Fifteen per cent of adults, they claim, never completely leave the transitional stages. According to Proffit and Mason (1975) "the typical adult swallow appears some time between ages 2 and 12". This ten year span, however, seems to be inordinately long.

2.6.1 Infantile Swallow

Virtually 100% of all normal infants thrust the tongue between the gum pads during the act of swallowing. If the infant did not thrust the tongue during swallowing it would be regarded as abnormal with a pathological entity involved.

During suckling (Roth and Calmes, 1981), the lips are postured around the nipple (or artificial teat), the jaws are apart, and the tongue is between the gum pads. The mandible elevates and slightly protrudes, carrying the tongue into contact with the nipple. The tongue then moves, or is moved, upward and slightly backwards. This has been revealed by the studies of Ardran, Kemp, and Lind (1958a, 1958b). There is the possibility that tongue elevation is aided in part, or almost completely, by elevation of the mandible during the compression stage of suckling. However, the tongue may be doing most of the work on its own - this is uncertain.

During the compression stage, the tongue dorsum is firmly pressed against the vault of the hard palate, while the tip of the tongue is positioned against the underside of the nipple.

According to Moyers (1964a) the facial muscles play the primary role in stabilising the mandible during suckling and swallowing in the infant, rather than the muscles of mastication.

During the next phase of suckling, the mandible drops slightly and, through a combination of positive pressure on the nipple by the tongue and negative pressure created by dropping the mandible, milk is expressed into the pharynx. When sufficient milk has collected on the dorsum of the tongue, the posterior part of the tongue descends, the soft palate elevates and the milk

enters the oropharynx. The tongue then repeats its cycle. This process is also described by Rix (1953), although he emphasises that the bulk of the lower lip remains in apposition with the ventral surface of the tongue, but its everted margin lies against the breast to form a seal with it and to help support it. The margin of the upper lip completes the anterior seal.

Gwynne-Evans (1951) described the change in the shape of the tongue when milk is expressed. The longitudinal groove changes at the front as the anterior margin of the tongue curls up to initiate a wave of pressure on the areola. With the progressive shifting of the longitudinal grooving of the tongue from below backwards, the milk is forced to the back of the mouth to be "squirted", with the aid of the mylohyoid muscles, through the isthmus of the fauces.

Scott and Symons (1971), in one of the more complete descriptions of suckling, point out that the baby forms an elongated teat from the nipple of the breast, drawing it well back into the oral cavity. During the greater part of the suckling process the vestibule of the mouth is in open communication with the main oral cavity. Contraction of the buccinator muscles and the supporting action of the buccal pad of fat in the substance of the cheeks prevents them from being drawn inwards between the gum pads. The stimulation of the nipple during suckling sets up a milk ejection reflex which is regulated by a combined neuro-hormonal mechanism whereby milk is expelled from the breast.

Dellow (1976) described this neuro-hormonal mechanism (Fig. 73). He identified the elements in the conjoint response of mother and child in suckling. The automatic and rhythmical motor activity of the neonate, along with periodic swallowing, receives its integrated control from the hind brain

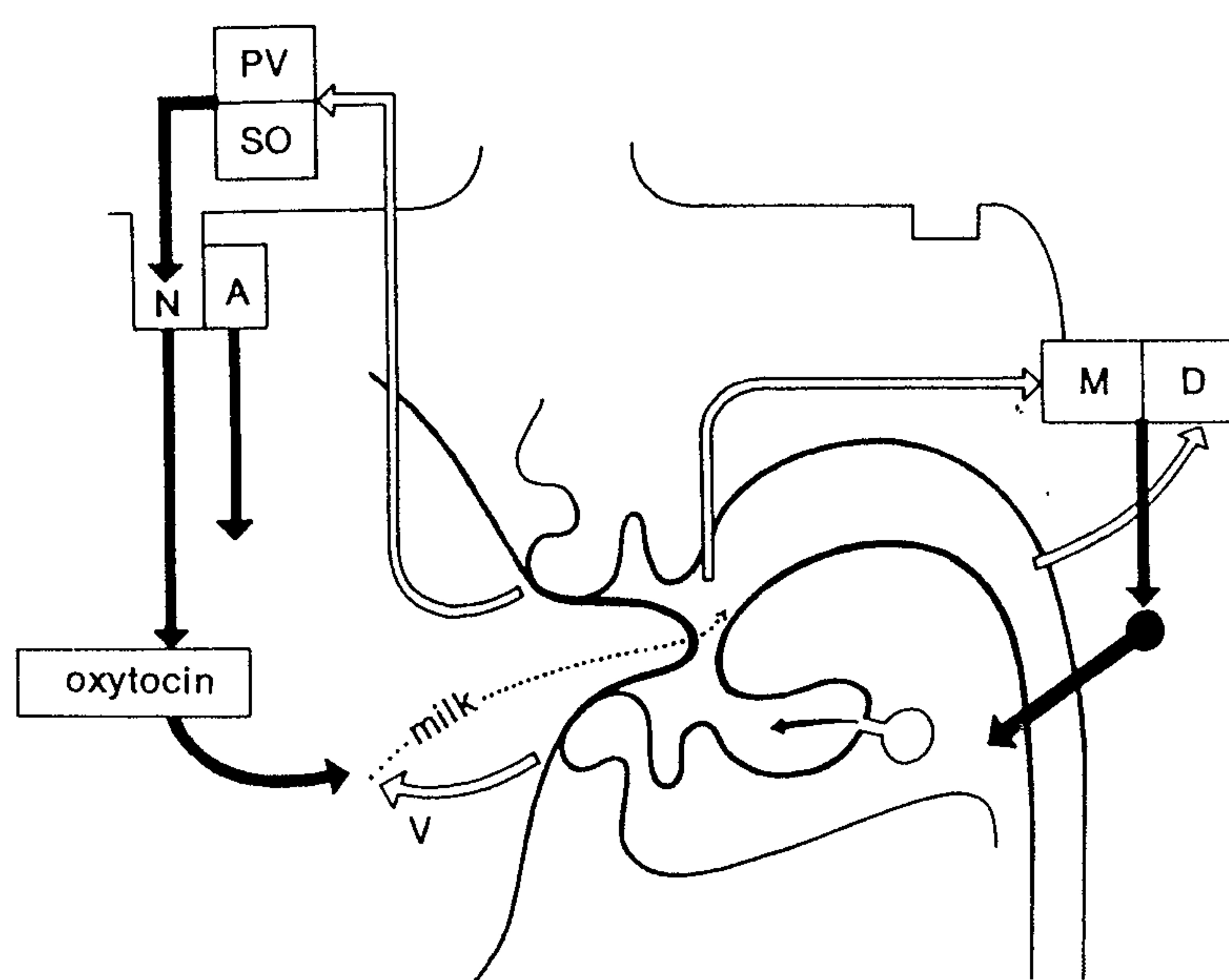


Fig. 73 . Mother-child suckling responses. (Dellow, in Sessle and Hannam, 1976)

(M,D), each act being triggered by appropriate stimuli of the anterior and of the posterior parts of the mouth. All other things being equal, the cessation of an ingestive period of suckling is presumably through gastric distention, and the post-absorptive chemical state influencing limbic and hypothalamic centres. Tactile, muscular, and gustatory stimuli cause a reflex flow of saliva which assists in the labial seal on the nipple. The development of the conditional salivary response also follows. The thrusting and closure of the infantile lips and gum pads upon the peri-areolar tissue is responsible for milk removal, but true physical sucking is a minimal factor. The main mechanism comes through the milk-ejection reflex of the mother; peri-areolar stimulation acts through the paraventricular (PV) and supraoptic (SO) nuclei of the hypothalamus to release oxytocin from the neurohypophysis (N), this in turn causing smooth muscle responses in the alveoli and lactiferous ducts. Milk production is assisted via prolactin from the adenohypophysis (A) while at the local level, the suckling act stimulates the release of vasodilator metabolites (V) which increase blood flow and favour milk production and release. The hypothalamic and renal controls of fluid balance are implicated in both individuals, the satiation of the infant at the expense of fluid loss and thirst in the mother.

Moyers (1973) noted a fairly rigid patterning of suckle-swallow-respiration sequences. Thus, the child who suckles twice before swallowing usually follows this rigid pattern, irrespective of the rate of the flow of milk. Also rhythmic elevation and lowering of the jaw provides a sequential change in position of the tongue in coordination with its suckling contractions.

Roth and Calmes (1981), also, give suckling a broader perspective. Suckling, to them, constitutes the primary oral experience since it provides the oral environment of the newborn infant with its first exposure to the outside world. They also point out the rhythmic nature of suckling saying that it

involves rhythmic movements of the jaw and tongue in particular, with each cycle lasting about $1\frac{1}{2}$ seconds. They draw the distinction between suckling and sucking as well, saying that suction may also contribute to the expression of milk. Such nutritive suckling may last for several minutes, with swallows interspersed between a variable number of sucks. In such instances the swallow is not a distinct event clearly separated in time from the suck, but merges with it.

Cole and Cole (1980) note that the above pattern of swallowing is relatively consistent during the first 12-18 months of life. After that time the pattern gradually changes due to a number of factors: (a) the infant assumes an upright head and body posture, (b) the incisors have erupted, (c) first molars have erupted enabling occlusal contact, (d) the diet now incorporates textured and solid foods, (e) the suspension of the tongue is altered because of the enlarging oral cavity, and (f) the Trigeminal nerve now takes over the function of stabilising the mandible from the Facial nerve. These factors lead to a transition stage.

Regarding this infantile swallow stage, Proffit and Mason (1975) record that the tongue fills the space between the gum pads, or later, the teeth. The lips are active in suckling movement and the tongue is placed out between the dental ridges in contact with the lower lip and beneath the nipple. At first, lip activity is more prominent than tongue movements. They cite Bosma (1967) who called this phenomenon a front-to-back maturation of the oral structures, with lip "maturation" preceding that of the tongue. Later in infancy, increasing tongue movements are seen but the tongue-to-lower-lip apposition remains.

2.6.2 Transitional Swallow

This transitional period may last from the second to the eighth years of life (Cole and Cole, 1980) or second to twelfth year of life (Proffit and Mason, 1975). Earlier reports had the change from infantile to adult swallowing patterns occurring at about $2\frac{1}{2}$ -3 years of age (Gwynne-Evans, 1951), and later, from 1- $1\frac{1}{2}$ years of age (Moyers, 1964a). While the study by Lewis and Counihan (1965) found the change to be around the age of 5 years, which coincided with the observations of Rix (1953). Proffit (1972) suggested that retention of a completely infantile swallow into childhood would probably indicate neurologic damage, but surmised that it was reasonable to suppose that children mature at different rates in swallowing as in everything else, and that some lag behind.

In a limited longitudinal study, Proffit (1972) presented the following as the usual picture of swallow transition: at first the tongue is carried below the palate, extending between the teeth anteriorly and laterally. During a swallow in this tongue position, there would be light contact and even pressure on the palate. Tongue tip pressure may be high relative to lateral pressure, due to the low absolute pressures at all locations. Normal dental occlusion, perhaps with a large freeway space, is theoretically possible with this type of swallow.

As a child moves toward an adult swallow, the jaws are brought more closely together while swallowing, so that posterior teeth make contact or nearly make contact. Lateral pressure in the molar region increases as the tongue tip still protrudes between the incisors. Anterior open bite malocclusion is probably associated with this initial swallowing step.

With increasing maturity, the tongue tip is elevated behind the

maxillary incisors, and the teeth are increasingly brought into contact, carrying the sides of the tongue higher into the palate which is deepening. At this stage, pressure by tongue tip and sides increases, but tongue tip pressure increases more quickly. At the conclusion of the tongue tip elevation, the clinical tongue thrust has disappeared, but tongue pressure on the incisors is high.

Not all swallows in a child who is in a transition period will show the characteristic pattern of a particular phase. The transition is a gradual one, and individual swallows may revert to the pattern of the previous phase, or anticipate the next phase.

The final stage in the transition apparently is an accommodation to the containment of the tongue by the teeth. This is seen in the tendency for the tongue tip pressure to decrease from the maximum which occurred at the time of clinical change to adult swallowing. In the case of the children in Proffit's study who were followed for four years, not until tongue tip pressure decreased from the peak following transition, did improvement in anterior open bite appear. This pattern, he says of swallow pattern transition, is consistent with clinical observation and cineradiographic studies. Clinically, the only consistent similarity of the tongue thrusters, in his study, is in protrusion of the tongue tip. In 1975, Proffit and Mason suggested that a child with a tongue thrust swallow is most likely to be an individual who has not yet learned the adult pattern, not one who has somehow learned the wrong thing.

Other points to consider (Cole and Cole, 1980) are, that the tongue now demonstrates a much greater specificity during functions such as mastication and speech, it no longer "acts like a mop". Also, the entire tongue is gradually positioned slightly more posteriorly during this period, not just

because of the gradual recession of the oropharyngeal lymphoid tissue.

On a neurological note, Bosma (1973) described this maturation process as a "cerebralisation" of oral activity, wherein the reflex actions of the anterior oral musculature yield progressively to voluntary motions. Thus swallowing, originally a totally reflexive process, develops into a complex, integrated voluntary-reflexive one during infancy and early childhood.

2.6.3 Mature Swallow

The rest position of the tongue is slightly posterior to that observed during the infant and transitional periods. Molar contact becomes increasingly frequent. There is less facial muscle activity than during the infant and transitional periods. The tongue tip now contacts the area of the rugae or the dentoalveolar junction at the initiation of the swallow. During the transitional period the tongue tip is more often found on the lingual surfaces of the maxillary incisors during the initiation of swallowing. Other features have been discussed in a previous section.

A comprehensive discussion of these stages in swallowing maturity was given by Subtelny (1965) in which he covered:

- (1) the embryonic and foetal stages of development;
- (2) the neonatal stage;
- (3) the physiologic stage of eruption of deciduous teeth;
- (4) the transitional stage of development; and
- (5) the permanent-dentition stage.

Clearly, it is the transitional stage of swallowing that is of crucial importance to the concept of normal and abnormal swallowing.

Pierce (1978) cited the findings of Fletcher (1974) and described the maturational process in four stages, with two stages covering the aforementioned transitional stage: (1) the infant newborn stage, (2) the primary tongue thrust stage, (3) the transitional tongue thrust stage, and (4) the mature stage. Stages 2 and 3 cover the intermediate phase from infant to mature swallow, with stage 2 covering from infancy to the beginning of the mixed dentition. Quoting the study of Hanson and Cohen (1973), in which

42.1% of the sample of 4 year 9 month old children showed a mature swallow pattern, while 57.9% still showed a tongue thrust or infantile pattern of swallowing, Pierce also brings up the concepts of 'normal' and 'abnormal' in relation to these figures. In Stage 3, covering the ages of six to ten years (the mixed dentition stage), Pierce points out that the child may revert to an infantile swallow as the deciduous teeth are exfoliated and the permanent ones erupt. The tongue being thought to thrust forward or laterally in order to "plug up the holes" of the missing teeth. Milne and Cleall (1970) called this functional adaptation a "physiologic tongue thrust".

It would appear from these studies that the transitional stage may be regarded as a diagnostic 'no-man's-land' if we are to take any one age group during this period, and studies based on cross-sectional data (Andersen, 1963) are bound to have limited significance.

It seems that there is still much to be learnt about the transitional stage leading to the mature stage. Although the tidy arrangement of swallowing from infant suckling, to transitional stage, to adult mature swallow may appeal to some, the concept of transition rests mainly on the questionable findings of limited longitudinal studies performed by Milne and Cleall (1970) and Proffit (1972). There appear to be no other studies to substantiate these. Other studies of a cross-sectional nature have been recorded (Fletcher et al., 1961; Werlich, 1962; Andersen, 1963; Tulley, 1964) but only one other longitudinal study has been undertaken. Unlike the study of Proffit (1972) which was taken over four years, this one (Hanson and Andrianopoulos, 1982) was taken over more than thirteen years. Unfortunately, no attempt was made to refute Proffit's findings, although a clearer picture of the incidence of tongue thrust swallowing with age was presented. One of the conclusions reached was that the authors would not be able to predict which children

would still be tongue thrusting during or after adolescence. In addition, the work of Milne and Cleall (1970) has been criticised (Barrett and Hanson, 1978) on the grounds that they studied only children with normal occlusion and normal swallowing patterns.

In another study, albeit cross-sectional, Stanley and Lundeen (1980) found notable fluctuations in the incidence of tongue thrust between 8 to 12 years of age.

The conclusions made by Proffit (1972) after studying ten subjects, for four years, and the conclusions deduced later from these studies (Proffit and Mason, 1975; Proffit, 1977) that the reversion to an infantile stage of swallowing may be part of a normal orofacial development pattern for some growing children, and that, in particular, the transition takes place between the ages of two and twelve or puberty, seems to be unsupported by the limited data. A longer-term study with a larger sample may be in order. Subtelny (1973) drew attention to the lack of adequate evidence to support the generalisations made from cross-sectional studies, upon which much of our learning is based. He wrote that "there is no well-defined longitudinal reference of normal tongue growth and swallowing activity as it relates to orofacial structures".

In conclusion, it would seem that we are still no closer to identifying, or predicting accurately, at what age the mature swallow will develop, except that it would seem reasonable to assume that the change is more likely to occur at a young age (3-5yrs). A significant proportion of children, however, do not make the transition until a considerable time later (8-12yrs), if at all. Proffit (1977) has even suggested that "15 per cent of normal adults never do totally leave the transition stages".

2.7 Normal Tongue Size, Posture, and Rest Position

This section not only deals with these three aspects of the tongue, but also acts as an introduction to later sections dealing with tongue function, malocclusion, and associated orofacial disorders.

In synthesising opinions, Barrett and Hanson (1978) contend that there is general agreement that the mandible, in ideal physiological rest position, is maintained by tonus of the antigravity muscles to provide a distance of some 2 to 4mm between the occlusal surfaces - the "freeway space" or "speaking space". Tonus of labial muscles should provide an easy but constant contact of upper and lower lip. They cite recent research that indicates a mild static pressure of lips to teeth, resulting from a continuous negative intraoral pressure.

Furthermore, tonus in the lingual muscles should supply a convexity to the tongue corresponding to, and only slightly less than, the curve of the palatal vault. The tip of the tongue is contained within the dental arches and it may be elevated and retracted from the teeth or may contact a point anywhere from the incisal edge of the lower incisors, which are positioned not far from the rugae when the mouth is closed, to the upper alveolar ridge. The rounded dorsum is a slight distance below the hard palate, with the posterior segment in contact with the soft palate (Fig. 74A). In function, as has already been discussed, the lips come together before the teeth as the teeth move into occlusion. There is a certain amount of redundant height in the lips in comparison to dentoalveolar height. From such a resting posture, and with normal structure, the swallowing of saliva would require: only mild contraction of the antigravity muscle group to close the freeway space; that the lips provide an existing seal to assist in sucking the bolus onto the already poised and elevated dorsum; and that minimal effort is required throughout this function.

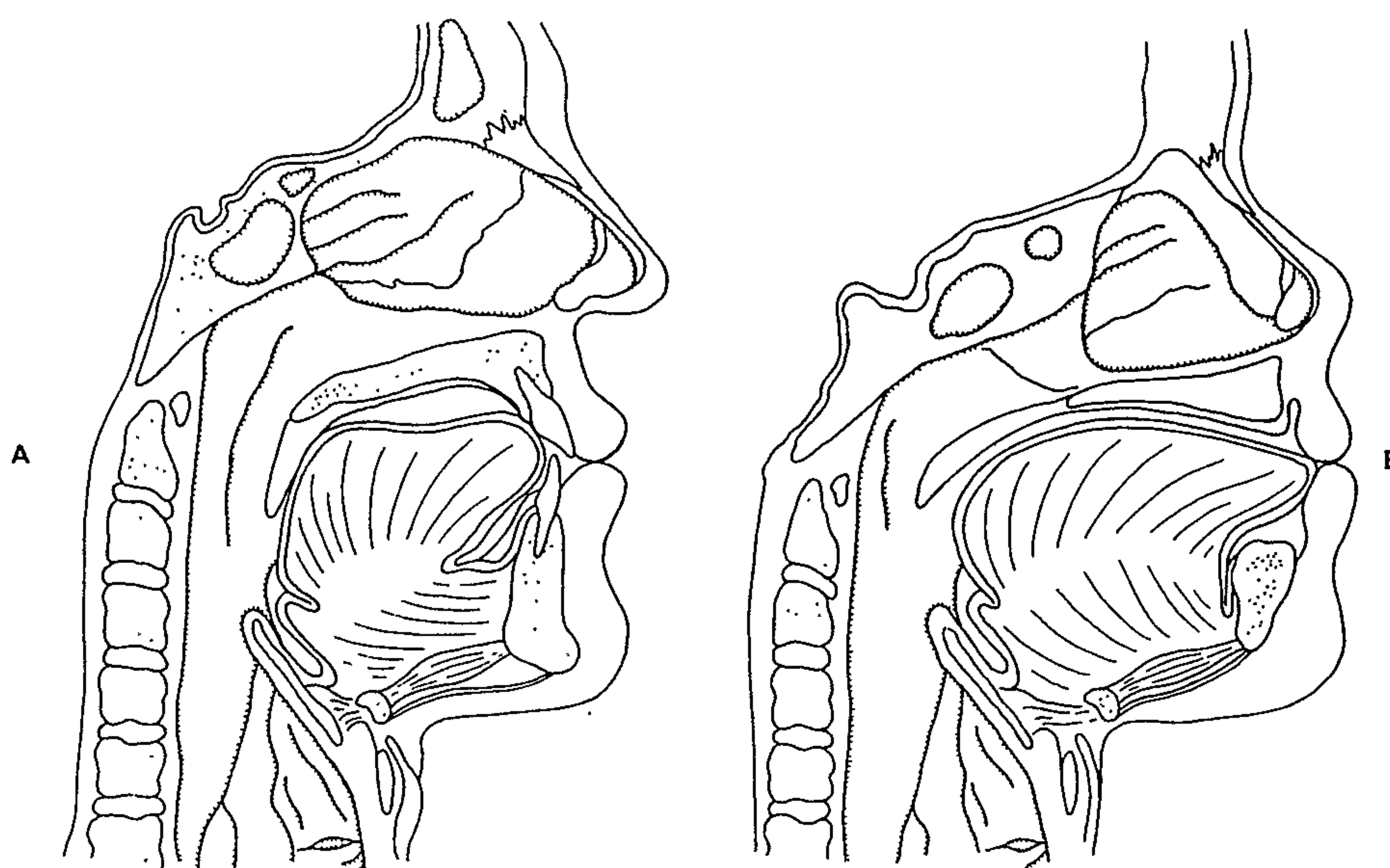


Fig. 74 Tongue and lips in rest position.
 A. Usual posture after the age of tooth eruption.
 B. Infant rest posture. (Barrett and Hanson, 1978)

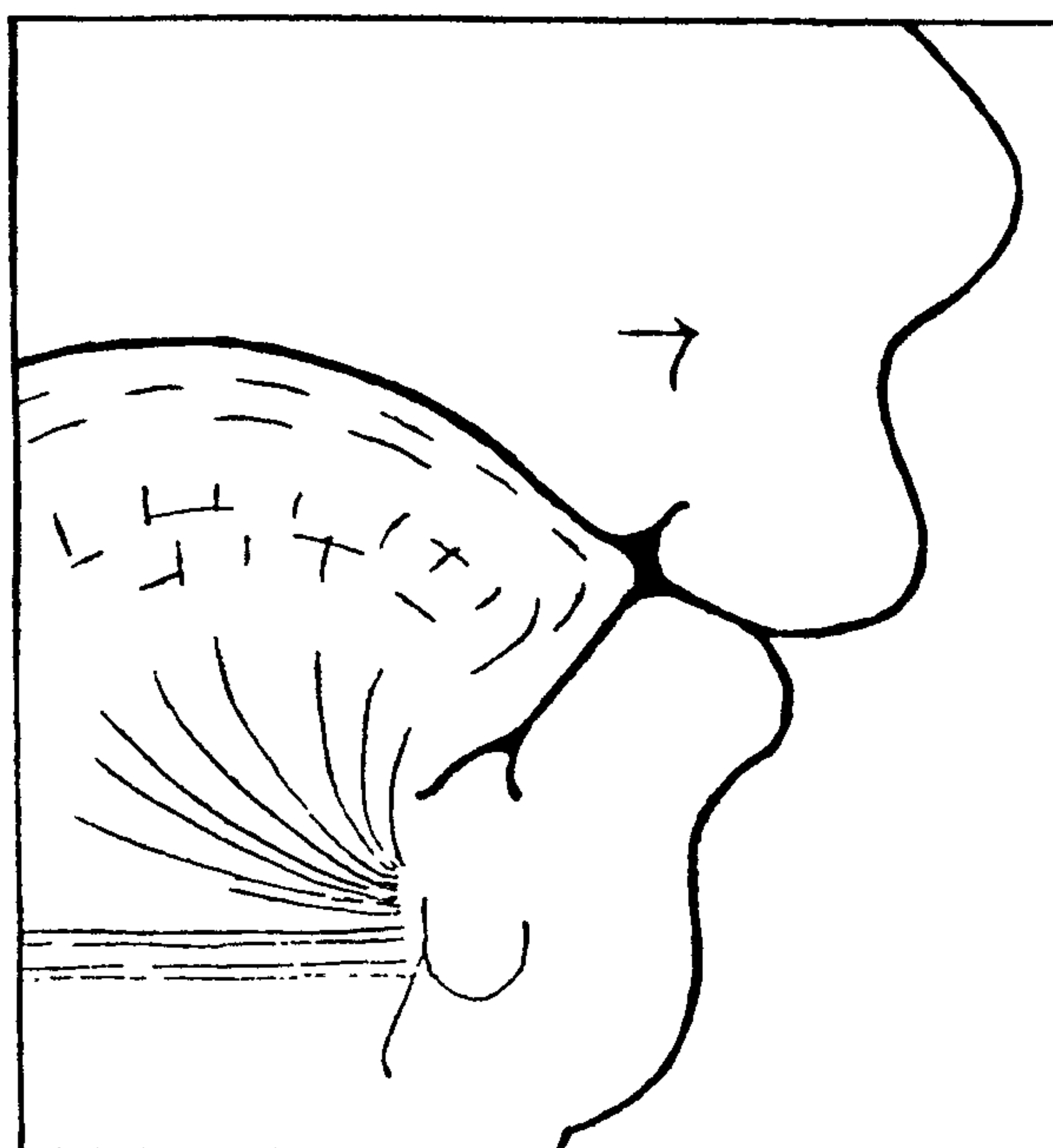


Fig. 75 Infant rest position. Lower lip makes principal contribution to anterior boundary of oral cavity, forming a broad contact with ventral surface of tongue. (Rix, 1953)

Of infant rest posture (Fig. 74B), Barrett and Hanson say that there is a great redundancy in the lips, causing a marked pursing, or protrusion of the lips if the mandible is elevated. The tongue fills the entire oral cavity; neither teeth nor alveolar bone has yet developed, so that the tongue overlies the lower gum pad in contact with the lips.

A similar description is given by Moyers (1973). Concerning the nature of the infant's tongue posture he says that the oral functions in the neonate are guided primarily by local tactile stimuli, particularly those from the lips and the front part of the tongue. At this age, the tongue is guided largely by tactile sensation. The posture of the neonate's tongue is between the gum pads and is often far enough forward to rest between the lips, where it can perform its role of sensory guidance more easily.

According to Brodie (1962), as quoted by Hoffman and Hoffman (1965), macroglossia is common at birth and the tongue completely fills the mouth whilst the tongue tip often protrudes between the lips. This anterior tongue positioning is necessary to prevent encroachment upon the airway and to prevent choking. Bosma (1963) states, "the mechanism of pharyngeal airway maintenance is a principal determinant of the antero-posterior relationship between the tongue tip and the incisors". Later, head and neck posture develops in relation to the pharyngeal airway. If necessary, the tongue may protrude anteriorly to maintain the necessary pharyngeal airway.

Similarly Rix (1953) describes the infant as having a relatively large tongue, filling the mouth into which the dento-alveolar structures have not yet arisen. It meets the cheeks and lips across the "meagre" gum pads and it is the lower lip rather than the upper which makes a broad contact with the tongue anteriorly (Figs. 75, 76).



Fig. 76 Ventral surface of tongue maintaining contact with lower lip during changes of facial expression in the infant. (Rix, 1953)

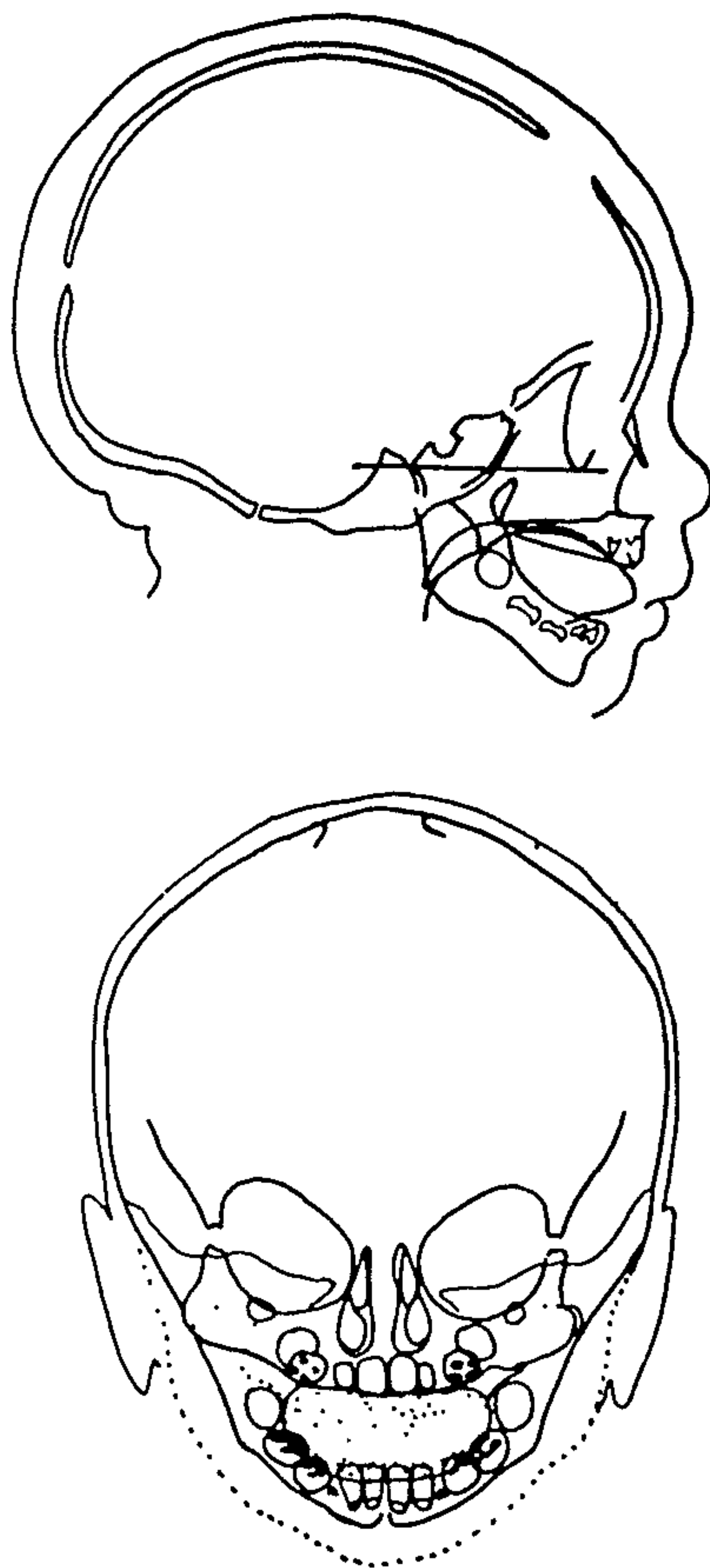


Fig. 77 Lateral and frontal tracings of infant head showing tongue-jaw relations. (Brodie, 1971).

Brodie (1971) also describes the tongue as filling the mouth in most infants at birth, its periphery flowing out to support the lips and cheeks (Fig. 77). Normally, it is gradually enclosed by the eruption of the teeth and the rapid development of the jaws and alveolar processes, but if the ratio between tongue growth and jaw growth is not harmonious, i.e., if the tongue remains disproportionately large, it is apt to be forced back and one of several responses must be made to the reflexes that guard the airway. Proffit and Mason (1975) drew attention to the rate of the tongue's growth in relation to other various parts of the body, quoting Scammon's (1930) work (Fig. 78). The clinical implication of the growth differential between the tongue and mandible is a natural tendency for the large tongue to be positioned relatively high and forward in the oral cavity in the early years of growth.

The pattern of sensory innervation of the tongue and oral mucosa, and the anteriorly directed tongue movements, are also factors in anterior positioning of the tongue in younger children (Proffit and Mason, 1975). The richer distribution of sensory nerve endings in the front of the mouth encourages "fronting" of the tongue tip as a means of generating tactile feedback. The universal emergence of bilabial and linguoalveolar consonant sounds at early ages in the speech acquisition sequence is related to this (discussed later).

Returning to Brodie's (1971) observation regarding tongue posture and airway maintenance, Proffit (1977) also points out the influence of the tonsils and adenoids. Under normal circumstances the tonsils and adenoids undergo spontaneous involution at puberty. Scammon's (1930) diagram reflects this change, although the pharyngeal lymphoid tissue was not included in his study. This involution is thought to affect the tongue position, allowing it to rest further posteriorly. However, if there is interruption to this process, then the

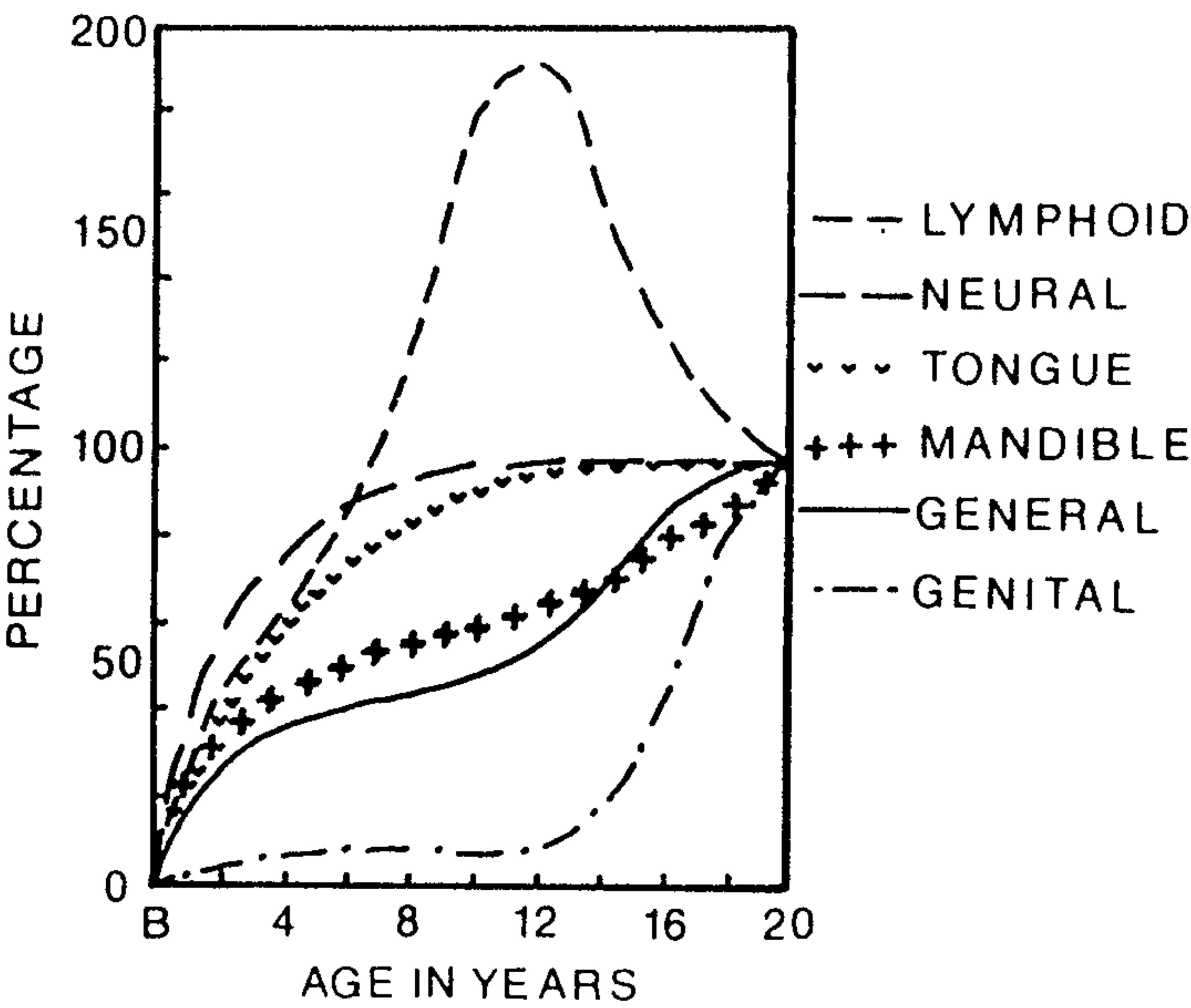


Fig. 78 Main types of postnatal growth of various parts and organs of the body. Lymphoid, neural, general body, and genital types, after Scammon (1930). (Proffit and Mason, 1975)

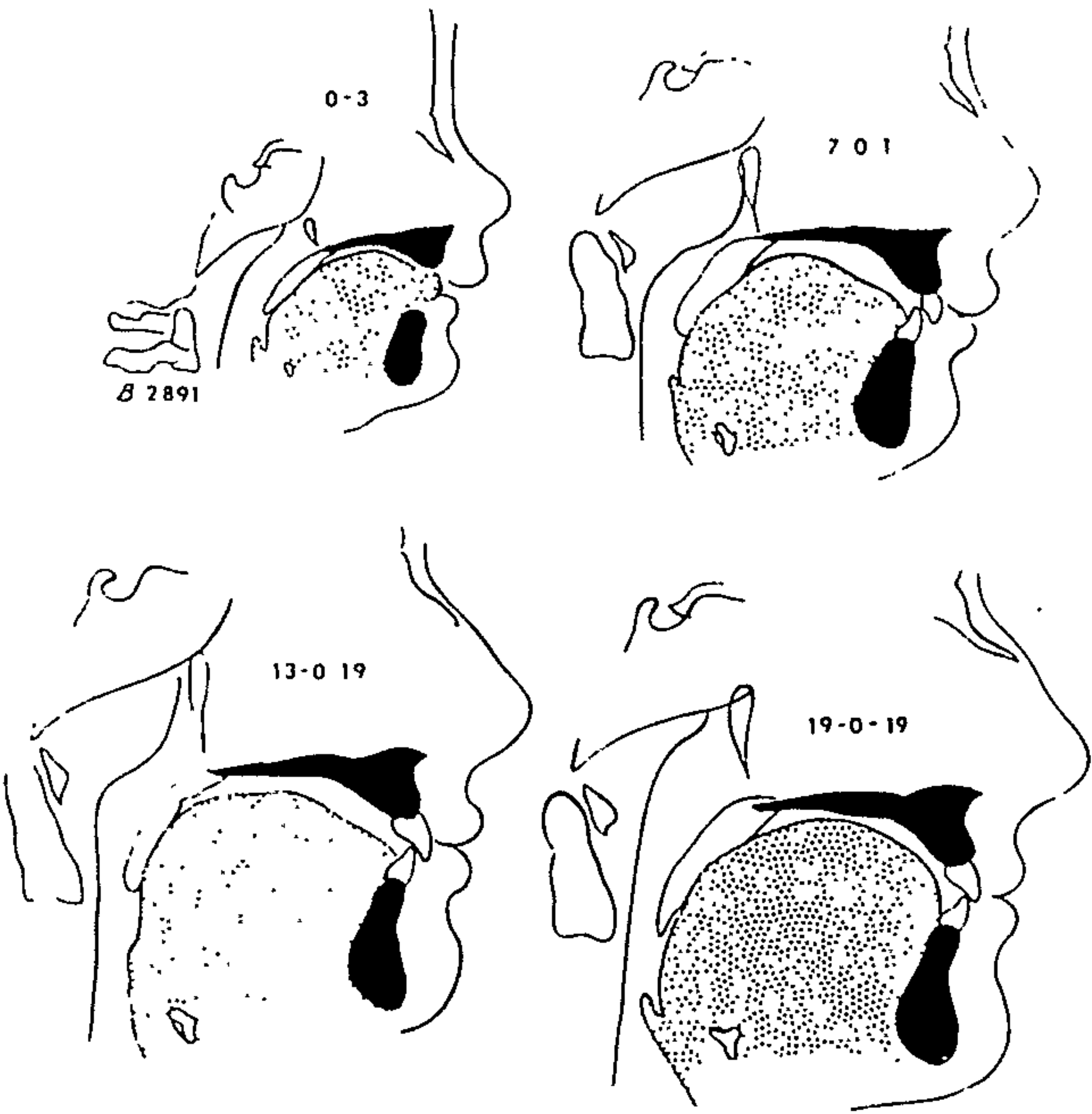


Fig. 79 Tongue tip position with growth and maturation. (Subtelny, 1965)

tongue may continue to adopt a forward resting position which, according to Proffit (1977), is the most likely cause of a malocclusion, such as an anterior open bite. Graber (1958) was an earlier author suggesting the possible importance of the resting postural pressures of the muscles, and the tongue in particular, rather than the forces generated during function, as active agents in the etiology of malocclusion. He refers to the tongue's size, shape, and postural position as being "a part of the mosaic of muscular mechanics".

Tulley (1969) cited the work of Winders (1956), Lear (1962), and Luffingham (1966) when stating that the tongue is probably more important than the surrounding musculature in its effect. Likewise, the speed and intensity of the rapid movements of the tongue in speech and swallowing are probably not so significant as the resting posture.

Subtelny (1965) recorded the change in tongue posture with growth and maturation. During the mixed dentition stage of development the tongue may still be large compared with the jaws and protrude between the teeth. He claimed that growth and development can correct the posture and the physiology of the tongue. The jaws grow adequately, so that they finally compare favourably in size with the tongue and the tongue is cradled within the mandible. Growth of the oral cavity and the pharyngeal cavities provides more space for function, so that the tongue no longer needs to be fronted and protrusive. He showed the change in tongue tip to lower incisor relationship on a growth basis (Fig. 79). He demonstrated how, with growth, the tongue tip frequently falls back relative to the skeletal jaws. This occurs despite the fact that the dentoalveolar processes are falling back in relation to their skeletal foundations and, because of this, the tip of the tongue must be capable of receding to a greater degree.

Peat (1968) in a cephalometric study of tongue position (with natural head posture) found:

1. There are two postural positions of the tongue for each individual. The first is a habitual postural position ("habit position") and presents:

(a) the tip of the tongue in contact with the incisor teeth and/or lips in 86.4% of the cases studied, in contact with both upper and lower incisor teeth in 61.3% of the cases, not in contact with the incisors in 13.6% of the cases; and

(b) the dorsum in contact with the hard palate in 33% of the cases and with the soft palate in 75.7% of the cases.

The second is a relaxed postural position and presents:

(a) a more convex curvature of the dorsum,
 (b) no contact of the tip of the tongue with the incisor teeth, and
 (c) no contact of the dorsum with the hard palate, although soft palate contact is maintained in 72.8% of the cases (Fig. 80).

2. The age factor must be considered in studies of the tongue position, as children have a higher dorsal height than adults.

3. Racial factors must be considered when soft-tissue morphology is examined.

4. In the "habit position", the contacts of the tongue with the incisor teeth and with the soft palate are the most persistent and are maintained, if necessary, at the expense of dorsal contact with the hard palate, from anterior to posterior (Fig. 81).

5. The "habit position" of the tongue is reflexly controlled so that when the feedback mechanism is broken by parting the lips or dropping the mandible slightly, the tongue drops back to assume the relaxed position.

6. Irrespective of the length of the oral cavity and independent of incisor relationship, the tongue moves forward from the relaxed position until

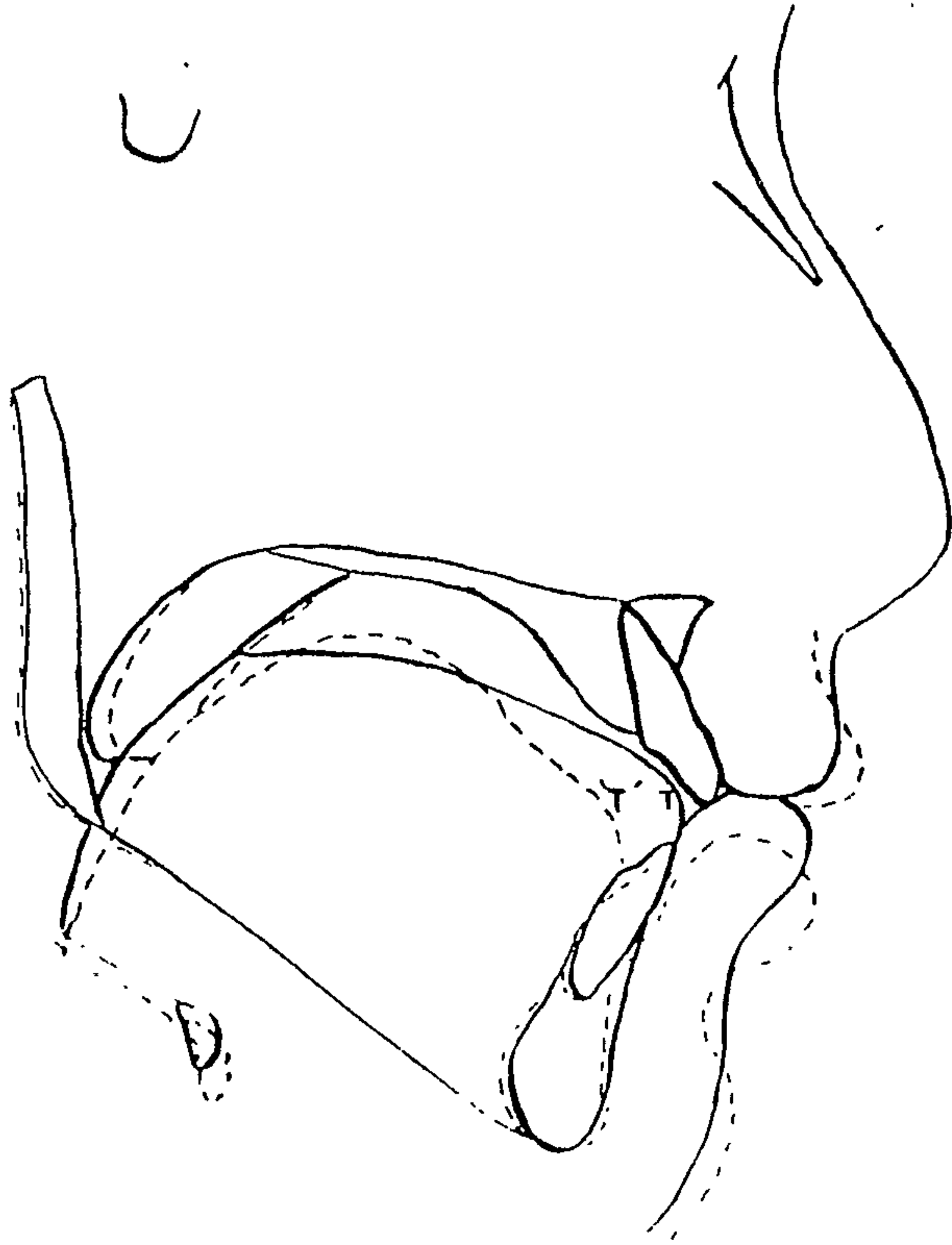


Fig. 80 Relaxed position superimposed on "habit" position. T, tip of tongue in habit position. 'T', tip of tongue in relaxed position. (Peat, 1968)

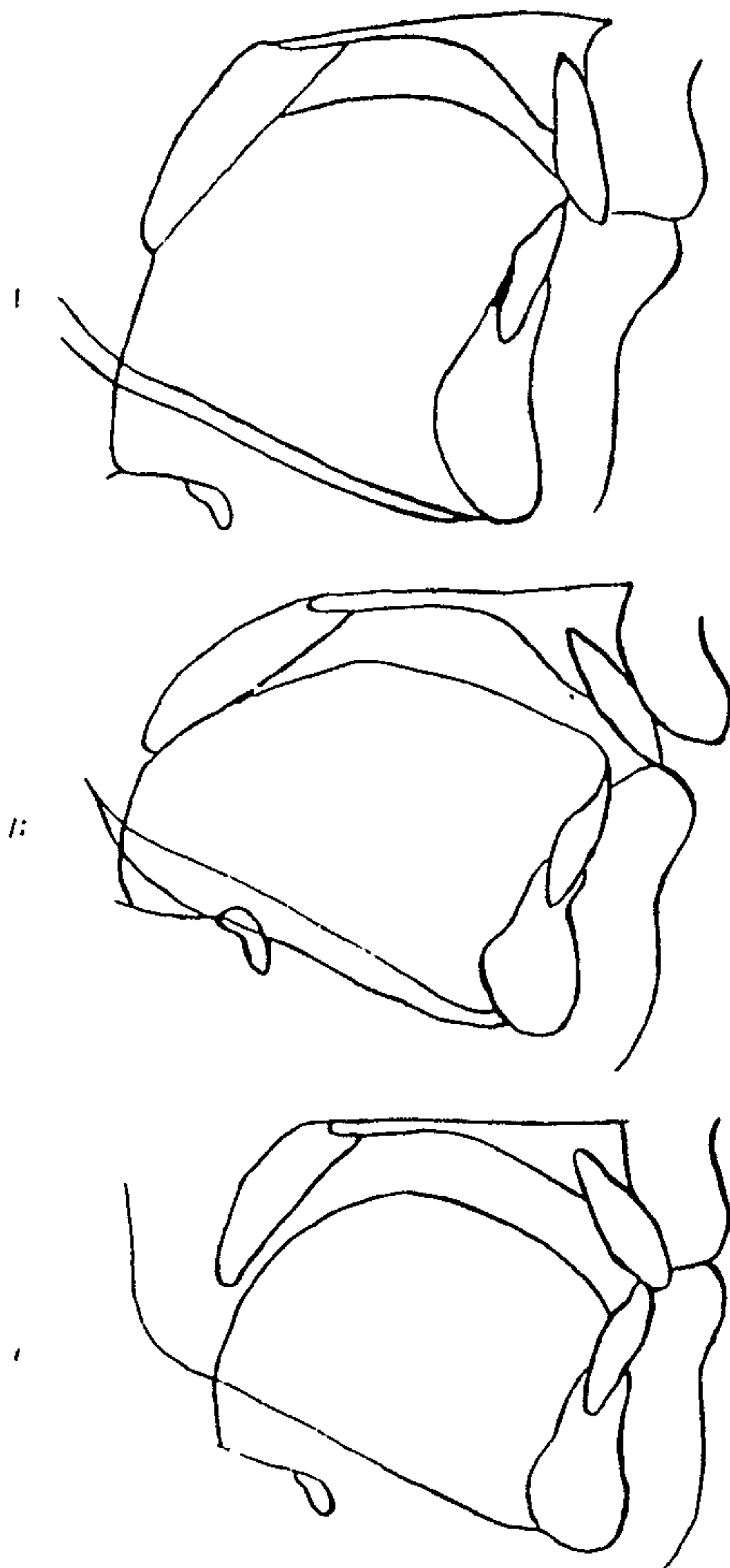


Fig. 81 Classification of tip-of-tongue contact.
 A, contacting upper and lower incisor crowns.
 B, contacting lower incisor crown only.
 C, contacting neither crown. (Peat, 1968)

contact is made with the anterior part of the mouth to fulfil a physiologic need.

7. The "habit position" of the tongue is reproducible and characteristic for the individual in 70% of the cases when the tongue-tip position and highest point of the dorsum are considered.

Ardran and Kemp (1972) using cinefluorography and Thurow (1977) all described normal tongue position at rest (Figs. 82,83) and were in general agreement with each other.

Bandy and Hunter (1969) devised a method of measuring tongue volume since no standardised method of measurement of tongue size or volume had existed for the living. What may be a "large tongue" to one investigator, they claimed, may not be large to another. They found that the volume "of the anterior portion of the tongue" can be measured with an average accuracy of $2.3\text{c.c.} \pm 1.4\text{c.c.}$

Bosma (1969) found that the most striking developmental adaptation of the human mouth is that of the mobile anterior portion of the tongue within the expanding oral cavity. He explained the concept of positional stabilisation of the dorsal portion of the mouth. He said it is a function shared with the pharynx and is also a part of pharyngeal participation in respiration. Throughout postnatal life, he said, the column arrangement of tongue, hyoid, and larynx is held forward maintaining patency of the airway in the pharynx and the laryngeal vestibule. This column is also held upward, with the tongue in approximation to the palate, so that the airway is in continuity with the nose, rather than the mouth. The soft palate is active in this approximation, separating the mouth from the pharynx (Fig.84A). With postnatal elongation of the vertical arrangement of the mandible, hyoid, and larynx, the composition

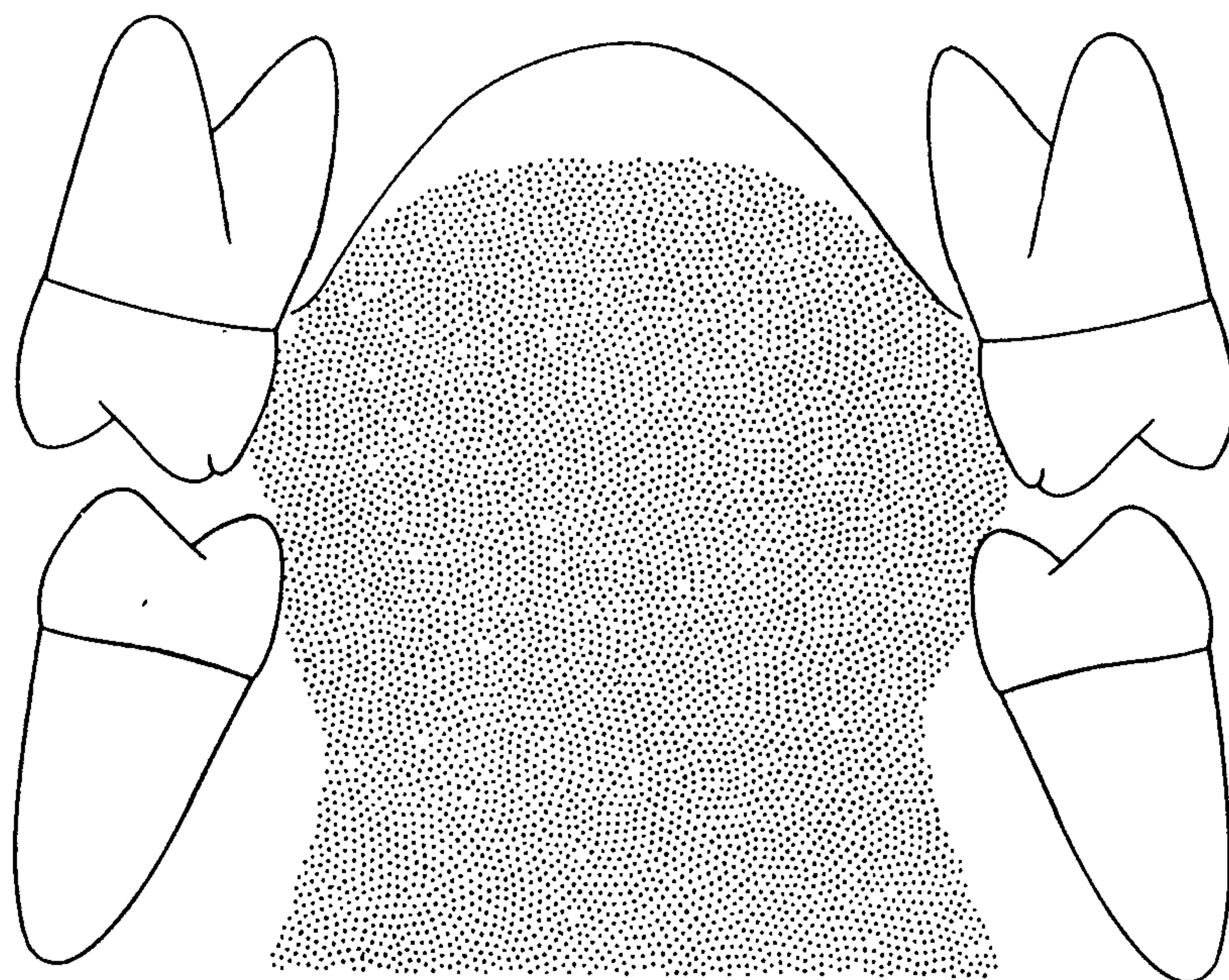


Fig. 82 At rest, the tongue normally contacts the palate and upper buccal teeth, with lighter contact on the lowers. (Thurrow, 1977)

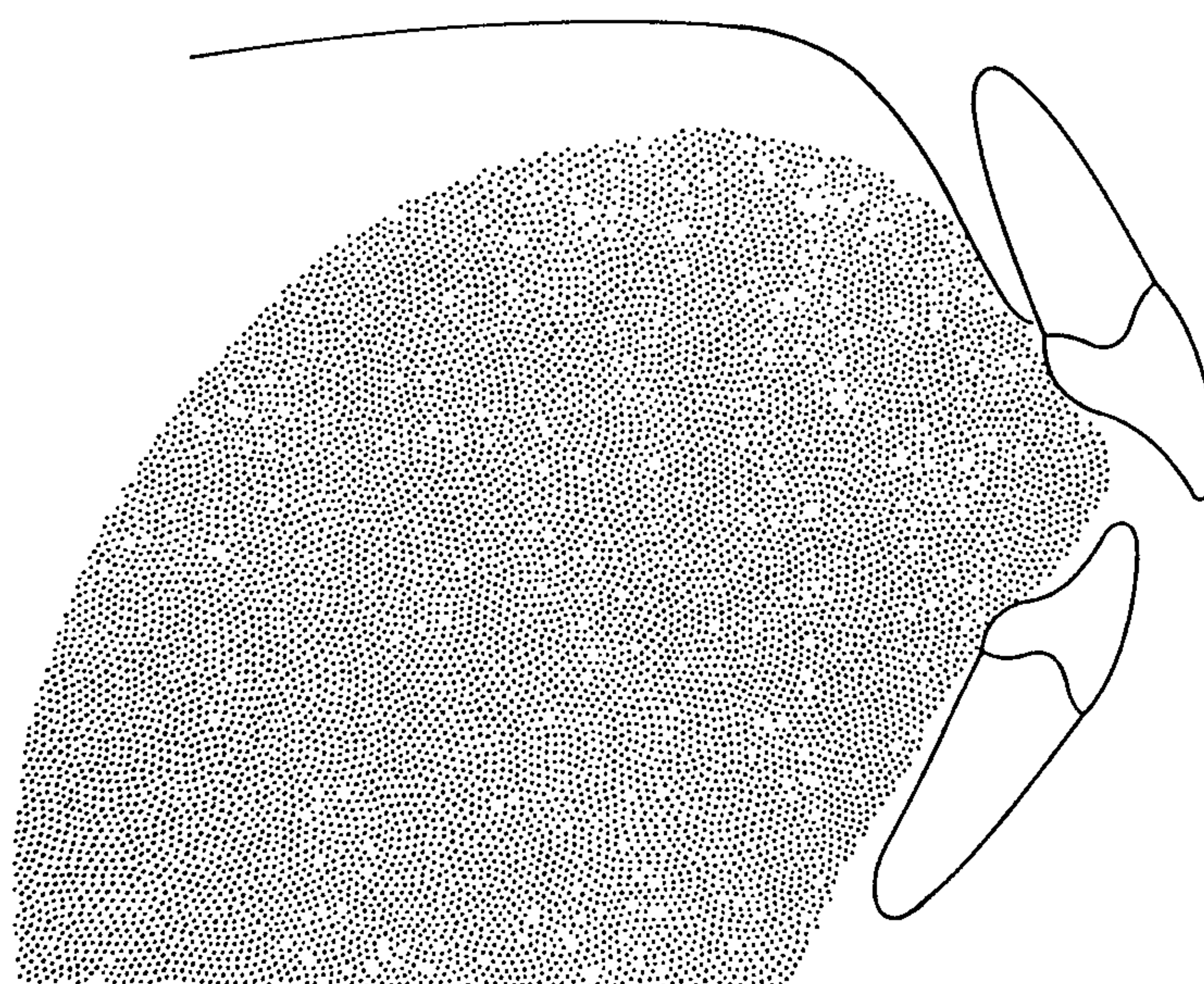


Fig. 83 Anteriorly most tongue contact at rest is with the palate and lower incisors. (Thurrow, 1977)

of the anterior wall of the pharynx is changed by the appearance of the tongue between the palate and the epiglottis (Fig. 84B). The mandible is a motor reference for this position of the tongue-hyoid-larynx column. After surgical shortening of the mandible in prognathic adults, the tongue mass is not displaced backward with the body of the mandible but, with the hyoid, is displaced downward. The anteroposterior diameter of the mesopharynx is thereby kept constant.

Thurrow (1975) comments on this aspect of airway maintenance. He suggests that posturing the tongue between the teeth could be an adaptive mechanism to secure a constant airway diameter, under adverse physiological or pathological conditions. He points out that any orthodontic treatment which would retract the anterior teeth should be considered carefully in the light of its effect on tongue space.

Vig and Cohen (1974) conducted a pilot study to compare the size of the tongue and the intermaxillary space in the child with that of the adult. This cross-sectional study of 75 ten year old children and 26 adults showed that the tongue becomes relatively smaller when compared with the intermaxillary space. They concluded that this relative decrease in the size of the tongue within the oral cavity is partly due to differential rates of maturation of the skeletodental and muscular elements, and partly due to the descent of the tongue and associated structures, which occurs with the growth of the cervical spine.

Cohen and Vig (1976) also retrospectively studied a group of 50 subjects. Using longitudinal radiographic material and their previous landmarks (Fig. 85) they came to some interesting conclusions. They found that, contrary to their previous study, the tongue becomes relatively larger during growth in

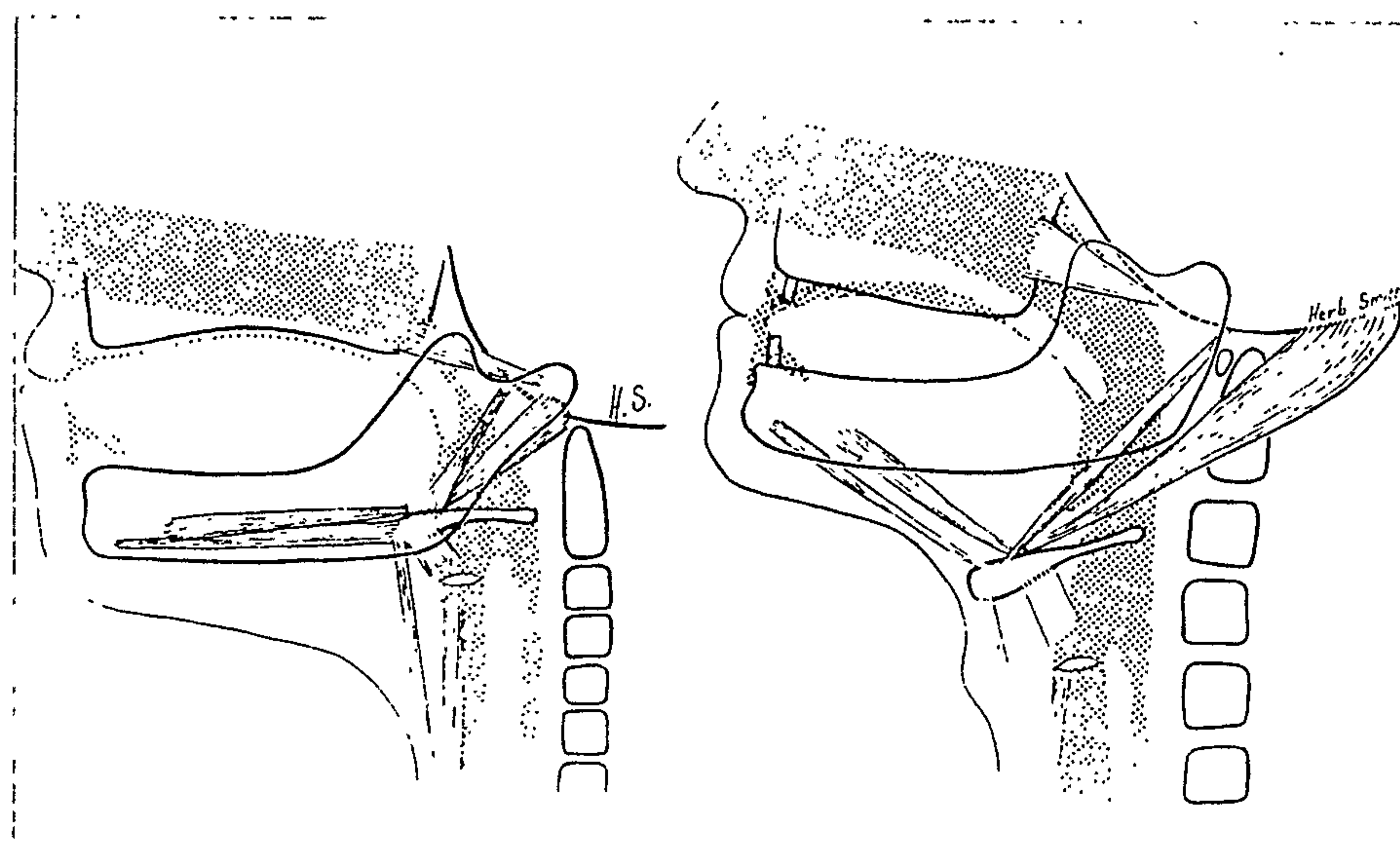


Fig. 84 Schema of spatial orientation of mouth and pharynx and of hyoid suspensory muscles in the newborn infant (A) and in the adult (B). (Bosma, 1969)

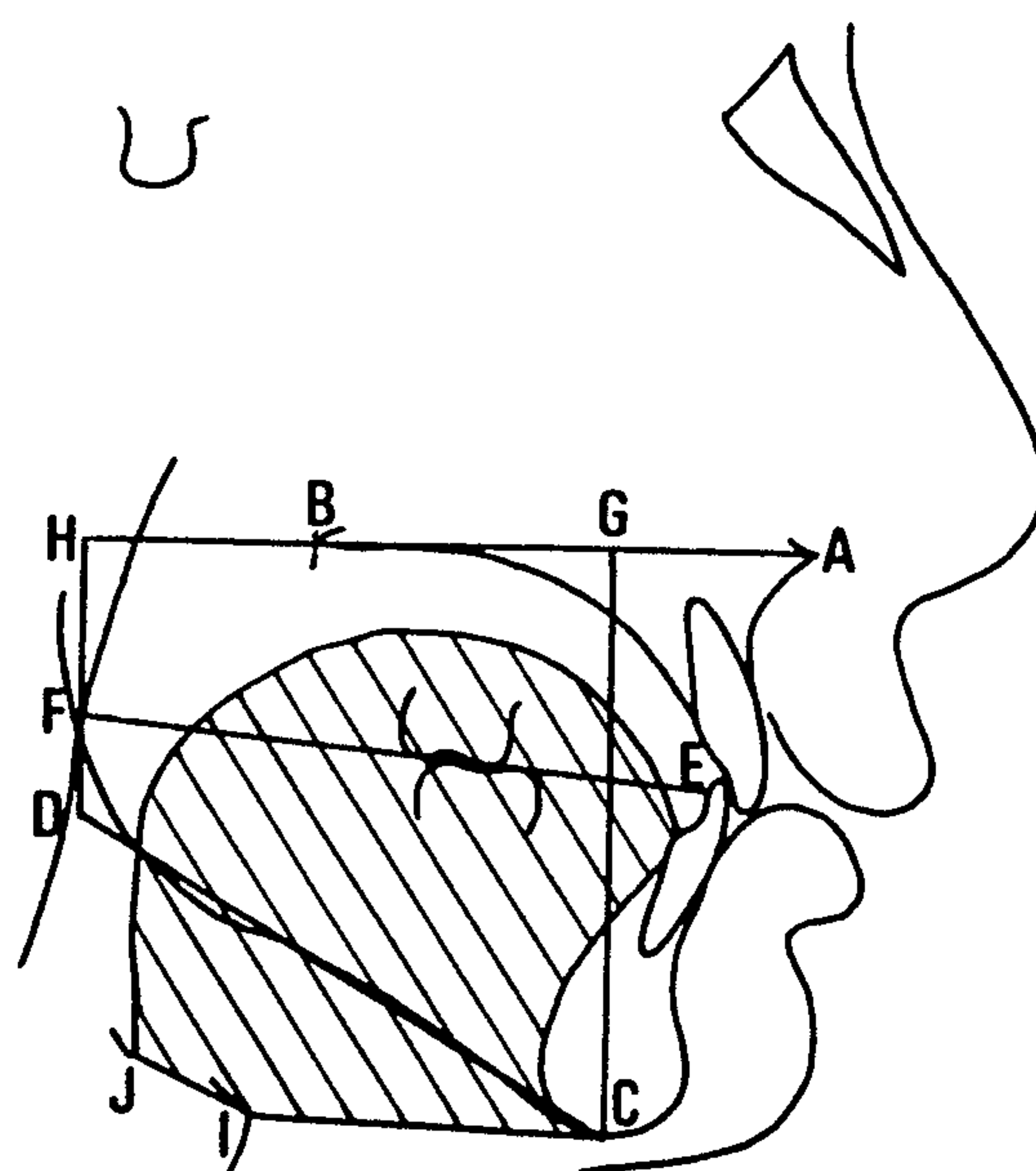


Fig. 85 A-B, maxillary plane. C-D, mandibular plane. E-F, occlusal plane. G-C and H-D, anterior and posterior intermaxillary space heights, these are perpendicular to the maxillary plane. The shaded area above C-I and I-J is the tongue shadow. (Vig and Cohen, 1974)

relation to the intermaxillary space. They speculated that the increase in relative tongue size is in fact in harmony with the descent of the tongue, and the two changes together maintain function during growth. They claimed that this study was more reliable than their first, pointing out its inadequacies.

In discussion, these authors point out that while it seems likely that the apparently disproportionate growth of the tongue may in some way compensate for its descent, one must guard against drawing conclusions on dynamic function from purely static records. They suggest reference to cineradiographic material may be of use. Previous cineradiographic work has established a relationship between functional movements and morphology. These findings, together with those of this study, suggest that relative tongue size and position are functionally integrated.

Dubner, Sessle, and Storey (1978) state that the tongue is normally maintained under postural control by the activity of the genioglossus muscle. Lowe (1980) conducted a study to correlate orofacial muscle activity and craniofacial morphology using control and open bite subjects, with particular reference to the genioglossus muscle.

Lowe was following up the suggestion from previous work that postural tongue activity could play an important role in the development of the dentition. In a previous study Lowe and Johnston (1979), using electromyography, noted enhanced genioglossus muscle activity together with an observed tongue protrusion in response to jaw opening in subjects with anterior open bite.

In this study (using a computer-based method to calculate the threshold incisor-separation position corresponding to a 20 per cent increase in base line

muscle activity for each of the muscles - genioglossus, masseter, and orbicularis oris), Lowe found a highly significant correlation coefficient between the genioglossus muscle threshold and overbite, suggesting that tongue postural activity may exert a definite influence on incisor position. In addition, low thresholds for the genioglossus muscle were related to under-erupted maxillary and mandibular central incisors. Since teeth normally erupt until they contact something, anterior open bite malocclusions may be due to the impeded eruption of anterior teeth as a result of a forward tongue posture.

Rakosi (1982) analysed tongue position by cephalometric radiography, and devised a method to determine tongue position and tongue motility, with specific reference to malocclusion.

(A) Tongue Position. Using a special template superimposed on a lateral cephalic radiograph, the space between the tongue and the roof of the mouth was defined and measured (vertical shading in Fig. 86).

Findings: 1. Root of the tongue. With anomalies in nasal breathing, a small space was found between the root of the tongue and the soft palate. A space in this segment was not always due to mouth breathing, but may also occur with a small tongue (in cases of deep overbite). A small tongue may also be seen with Class III malocclusion, but it is then in an anterior position, so that the space between the root of the tongue and the soft palate is large. In cases of mouth breathing, the space is also large.

2. Dorsum of the tongue. The dorsum is relatively high with Class II malocclusions. In cases of deep overbite, the dorsum is high at the back and low in front. In all other cases the dorsum tends to be low.

3. Tip of the tongue. The tip is retracted in cases of Class III and in Class II cases with nasal breathing, and even more so in cases of deep overbite. With Class II and mouth breathing the tip of the tongue is

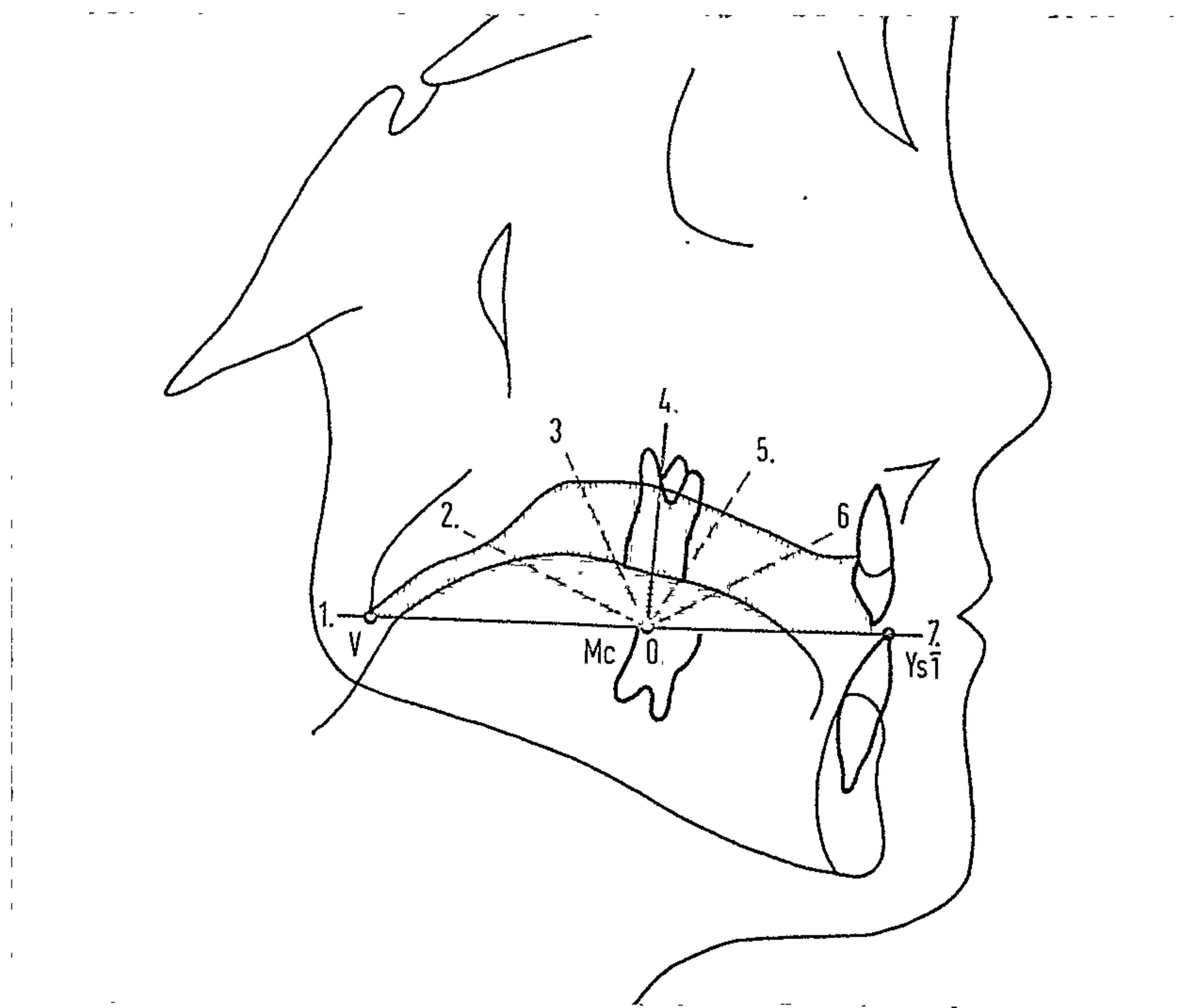


Fig. 86 Construction for assessment of tongue position. (Rakosi, 1982)

considerably retracted, whereas retraction is less with Class III and mouth breathing. In cases of open bite the tip of the tongue lies forward.

(B) Tongue Motility. For this, the position of the tongue in dental occlusion is compared with that in rest position. The template is used again to determine the height of the dorsum of the tongue on all seven lines, in both radiographs (horizontal shading in Fig. 86). The difference between occlusal and rest position is then calculated.

Findings: Changes in tongue motility are predominantly reflected by the position of the tip of the tongue. The position of other parts of the tongue does also change, though not relative to the mandible, but rather in conjunction with it. The changes in position of the tip relate closely to the different types of malocclusion. With Class II, the tongue is further back in rest position, with Class III it lies further forward. Rakosi assumed that the changes in position of the tip of the tongue relate to the tendency to mandibular malformation. Comparison of Class II and Class III malocclusions will show, for example, that in rest position the tip is retracted in cases of Class II, but shows forward displacement in those of Class III.

Having completed this section on the purpose, structure, and function of 'normal' deglutition in Man, the factors that characterise 'abnormal' lingual behaviour, both at rest and during function, will now be identified and discussed.

CHAPTER 3 TONGUE-THRUSTING and ABNORMAL TONGUE POSITION

- 3.1 Tongue Thrust Behaviour
- 3.2 Classifications and Identifying Characteristics of Tongue Thrust
- 3.3 Associated Muscular Activity
- 3.4 Incidence and Maturation Factors
- 3.5 Etiology
- 3.6 Criteria Associated with the Retention of Tongue Thrust
- 3.7 Clinical Diagnosis

CHAPTER 3

TONGUE-THRUSTING AND ABNORMAL TONGUE POSITION

3.1 Tongue Thrust Behaviour

As mentioned previously, tongue thrust swallow, tongue thrust, visceral swallow, reverse swallow, retained infantile swallow, deviant swallow, atypical swallow pattern, perverted swallow, abnormal swallow, traumatic swallow, deviate deglutition, anterior tongue positioning, and abnormal swallowing behaviour, are terms that, in general, have matched the various authors' usage, and for the sake of this discussion, are synonymous. "Tongue thrust" is the term popularised by Straub (1951) and usually refers to an anterior position of the tongue so that the tongue is visible between the teeth, although a posterior interocclusal position can also be noted. This may occur when the tongue is in an at-rest position, during swallowing and/or speaking (Rampp and Pannbacker, 1979; Proffit, 1977; Gellin, 1978).

The terms 'tongue thrust' and 'tongue thrust swallow' have generally been used in recent years, although Proffit (1977) would prefer to use the term "anterior tongue positioning". Essentially though, it is a positioning of the tongue against the teeth and a protrusion of it between them (Barrett and Hanson, 1978). Although he did not use a specific term, Angle (1907) described this behaviour similarly. He said it was a resting of the tongue between the upper and lower incisors, or "frequently protruding it more or less".

The aspect of tongue thrust of importance to this discussion is its significance. Tongue thrust has been noted in subjects with malocclusion, with

speech problems, or with both or none (Proffit and Mason, 1975). To these authors, tongue-thrusting was one, or a combination, of three conditions:

(1) During the initiation phase of swallowing - a forward "gesture" of the tongue between the anterior teeth so that the tongue tip contacts the lower lip;

(2) During speech activities - fronting of the tongue between or against the anterior dentition with the mandible hinged open (in phonetic contexts not intended for such placements); and

(3) At rest - movement of the tongue forward in the oral cavity with the mandible hinged slightly open and the tongue tip against or between the anterior teeth.

Tongue thrust, here then, is applied to its effect on the occlusion primarily, and on speech secondarily (covered in a later section). Proffit (1977) said that these terms implied that there was something abnormal about the patient's swallow, however, he claimed that this was not supported by research evidence. On the other hand Graber (1972) claimed that "the deforming force of the tongue as it thrusts continuously forward is obvious". He also said it was "obvious" that the act of swallowing, repeated so frequently, may have a profound effect on the maxilla and mandible, particularly if there is an abnormal swallowing pattern.

As previously mentioned, the tongue thrust swallowing pattern is a normal physiological phenomenon for a young child. During suckling the infant exhibits a tongue thrust pattern of swallowing. This continues to some degree throughout the "transitional" stage of development. Here the tongue changes to a mature pattern somewhere between the ages of two and twelve years (Proffit and Mason, 1975). What is of concern, therefore, is: (1) Is the swallow pattern delayed unduly from attaining maturity? and (2) Is this

contributing, or going to contribute, to a malocclusion? Proffit says that 15% of those with tongue thrust retain it into adulthood. Anterior tongue positioning in children below ten to twelve years is considered to be developmental, and after that age, chronic. It is necessary to distinguish between the two (Rampp and Pannbacker, 1979). Also, if the swallow pattern maturation is delayed, what are the reasons for the delay? Is it because of a malocclusion, deviant dentoskeletal pattern, detrimental oral habits, etc.? Unfortunately, this is the area of most controversy, since we enter the realm of the form/function argument. There are those who side with one side or the other, and those who feel that form and function both influence each other. Tongue thrust is an orthodontic problem if it interferes with and prevents the proper growth and development of the teeth, jaws, and face.

There seems to be enough evidence (Rogers, 1961; Winders, 1958; Graber, 1972; Truesdell and Truesdell, 1937; Moyers, 1964; etc.) to support the view that tongue thrust and abnormal tongue position can play a significant role in the etiology of malocclusion. This is the area under review.

According to Hoffman and Hoffman (1965) various physiological conditions such as neurological deficiencies, macroglossia, and Down syndrome may result in tongue thrust, and that in some situations tongue thrust may be normal. This has been mentioned previously and further aspects of these conditions will be examined as well.

3.2 Classifications and Identifying Characteristics

A greater appreciation for the manifestations and ramifications of tongue thrust behaviour can be gained by identifying the various characteristics and through classifying any patterns present.

Gwynne-Evans and Tulley (1956) were among the first to classify tongue-thrusting. They worked out a rudimentary classification in which eight basic types of abnormal behaviour were described. Included were patterns with and without circumoral contraction, with teeth open and closed, as well as other aspects.

Straub (1961) "in order to bring some semblance of order to the chaotic descriptions of patients with abnormal swallowing habits" attempted to classify these cases into four distinct groups:

Group 1. Anterior segment affected, with a diastema between the upper central incisors in most cases. Variation in tongue action is noted.

Group 2. Open bite, posterior and anterior, usually from the first molar forward.

Group 3. Side thrust, posterior open bite. The most difficult to correct according to Straub.

Group 4. "Close-bite", deep overbite case, the most difficult to detect. The patient, although having a deep overbite, opens sufficiently to accommodate the tongue between the teeth when swallowing abnormally. Straub felt that in these cases the swallowing pattern went undiagnosed until orthodontic treatment had been completed, the result being a patient with an open bite. The misconception here is that the tongue thrust has developed during treatment. Straub also felt that the placing of any "mechanical contrivance" such as a hayrake or a jig, in the mouth to keep the tongue from coming forward would end in failure, the reason being that the patient is able

to open far enough to allow the tongue to position between the teeth.

Straub illustrated these four groups with photographs of cases. He also included a case he called "severe" (Fig. 87). This he described as being the result of severe abnormal swallowing forces where the whole facial profile is forced into a complete bimaxillary protrusion. Both the upper and lower teeth are pushed forward by the tongue until there is a complete forward displacement of tooth and bone.

Hovell (1955) classified "atypical swallowing actions" into three groups:

1. Anterior tongue thrust with teeth together. The consequences being open bite, without overjet of the incisors, if the lips are competent and if the lips are incompetent, the typical end result is a Class II, Division 1 malocclusion.
2. Anterior tongue thrust with teeth apart. He found this group was often associated with sucking habits.
3. Tooth apart swallow with no tongue thrust. There being a gross retroclination of both upper and lower incisor teeth.

Whitman and Rankow (1961) described two cases of abnormal tongue position and function:

1. If the tongue is held higher in the mouth, a lateral tongue thrust may be present, thus causing an open bite in the buccal segments on one or both sides. This condition often being present in patients who appear to have Class II, Division 2 malocclusions. In these patients the characteristic rest position is one in which the tongue spreads out laterally and the mandibular dentition rests on the sides of the tongue in such a way that the pressure of the tongue is upward against the maxillary buccal teeth and downward against

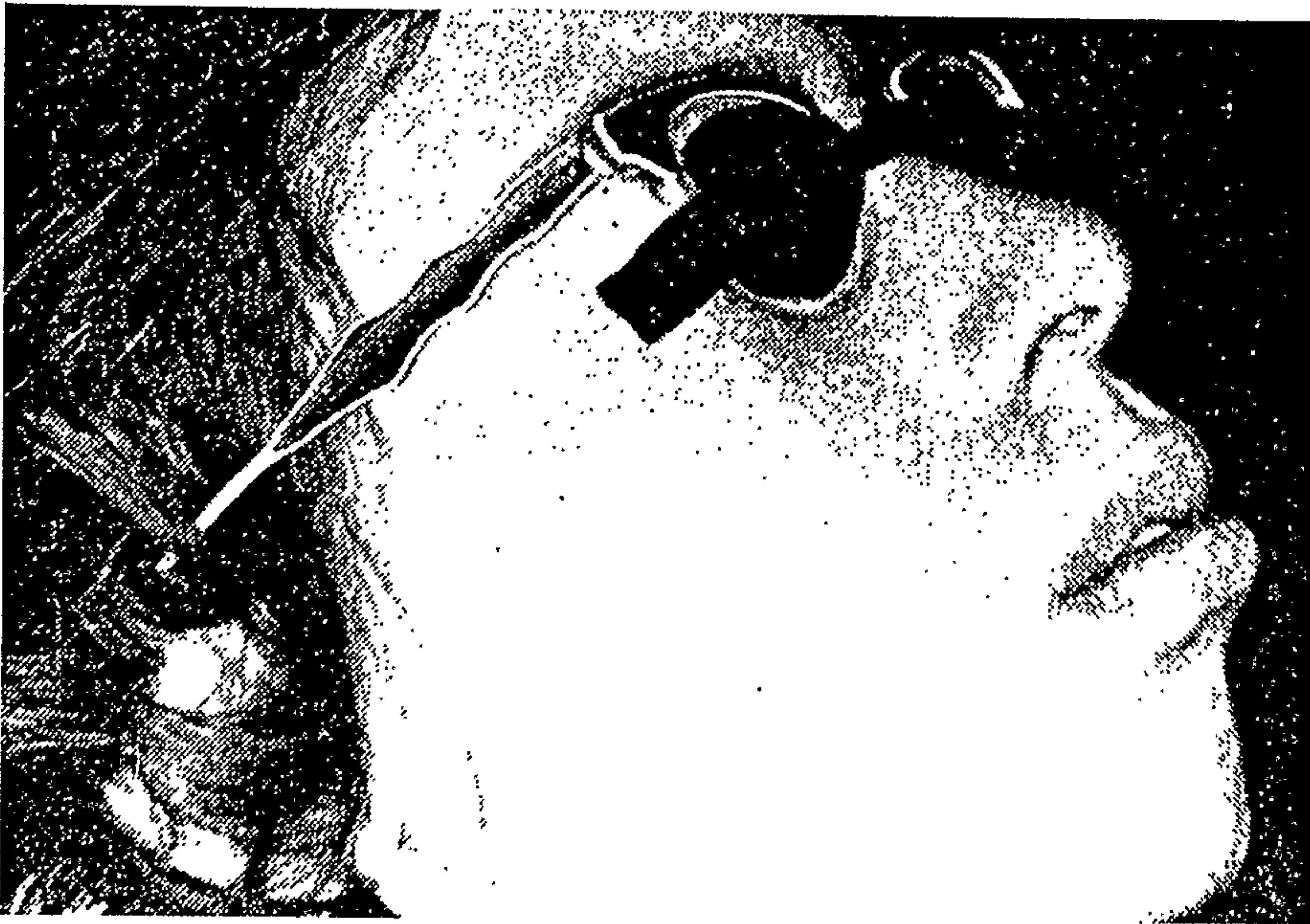


Fig. 87 Patient with bimaxillary protrusion, upper and lower teeth pushed forward by tongue. (Straub, 1961)

the mandibular buccal teeth. This prevents these teeth from erupting to their full occlusal height. The teeth are rarely brought into occlusion, but when they are occluded the appearance is that of a deep overbite case.

2. The tongue is held higher and protruded and there is an anterior open bite, as in "many" Class II, Division 1 cases, and also in Class I cases. If there is an incomplete overbite detected the patient probably has a tongue thrust which is camouflaged by the protrusion of the upper incisor teeth.

Moyers' (1964b) classification consisted of:

(A) Abnormal Posture: This includes any variation from the normal posture of the tongue tip resting on the lingual surface of the mandibular incisors. Two variations were specifically identified: (1) the retracted tongue in which the tongue is flexed markedly, with the tip withdrawn from the anterior region; and (2) the protracted tongue posture where the resting tongue lies gently between the incisors or atop all the mandibular teeth. The protracted tongue posture is a more serious problem compared to the retracted one, since it most frequently results in an open bite. Moyers identified two forms of this posture; (i) the endogenous and (ii) the acquired forms.

(i) Endogenous: here the tongue persists in lying between the incisors for unknown reasons. A mild open bite is seen but there is stability of the incisor relationship, and there is not a serious aesthetic problem.

(ii) Acquired: a simpler matter, usually the result of pharyngitis, tonsillitis or other nasorespiratory disturbances. It responds favourably after correction of the nasorespiratory problem. However, if the nasorespiratory problem is not relieved, orthodontic repositioning of the incisors will not be stable as the tongue will continue to position itself forward.

(B) Simple Tongue Thrust: This is a teeth-together swallow, the tongue thrusting forward on swallowing. There is a well circumscribed open

bite, usually between the canines, while the posterior teeth demonstrate "good occlusal fit". There may be an active finger habit or history of it. The tongue appears to be adapting to the morphologic pattern of the facial skeleton and the dentition. Circumoral muscle hyperactivity is also occasionally seen.

(C) Complex Tongue Thrust: This is a teeth-apart swallow with a forward thrusting of the tongue during the swallow. Circumoral contractions of the muscles are much more marked than the simple tongue thrust, and it is impossible to hold the patient's lower lip open while the swallow takes place. Moyers also made reference to the fact that it would probably be possible to further identify several more types of swallowing problems within this class.

(D) Retained Infantile Muscle Patterns: This refers to the retention into adolescence and adulthood of a swallowing pattern very similar to that of the infant. This happens with very few people. The etiology is unknown although this failure of maturation of the musculature is due to a serious neurologic problem in some cases. An open bite is present with minimal contact in each quadrant, usually one tooth. In addition, there is "extreme contraction of the facial mask" during the swallow, and mastication is very difficult.

Brauer and Holt (1965) devised a classification based on the deformity observed rather than the etiology, because of an inability to determine the nature and degree of all the etiologic factors. A detailed description was given. In summary it is:

TYPE I - Nondeforming Tongue Thrust.

TYPE II - Deforming Anterior Tongue Thrust,

Subgroup 1 - Anterior Open Bite

Subgroup 2 - Associated Procumbency of Anterior Teeth

Subgroup 3 - Associated Posterior Crossbite.

TYPE III - Deforming Lateral Tongue Thrust,

Subgroup 1 - Posterior Open Bite

Subgroup 2 - Posterior Crossbite

Subgroup 3 - Deep Overbite.

TYPE IV - Deforming Anterior and Lateral Tongue Thrust,

Subgroup 1 - Anterior and Posterior Open Bite

Subgroup 2 - Associated Procumbency of Anterior Teeth

Subgroup 3 - Associated Posterior Crossbite.

This classification was taken from a random sample of two hundred primary and secondary school students, in which all types and subgroups were seen.

Tulley (1969) broke down tongue thrusting into four classes:

(1) Tongue thrust as a habit. It is not seen past the age of 11. If the facial pattern is good and there is only a slight open bite and increased overjet with a Class I or Class II relationship then treatment is to be delayed. If the habit is persistent, treatment by placing the labial segments into the correct position is indicated.

(2) Tongue thrusting which is possibly endogenous or innate. This is a possible familial pattern. This, said Tulley, "will not respond to any kind of treatment".

(3) Tongue thrust as an adaptive behaviour. Patients are unable to effect an anterior oral seal with the lips at rest. The tongue is forward in functional movement, and postured forward over the lower incisors at rest to seal with the lower lip. There is an adverse skeletal pattern (high Frankfort-mandibular plane angle).

(4) Pathologic and grossly abnormal tongue problems. Macroglossia only is mentioned and is said by Tulley to be extremely rare.

Plainfield (1977) wrote an unusual article relating the "dentally traumatic swallow" to the wearing of full dentures and to speech production. He identified the normal swallow, and three dentally traumatic swallows (Fig. 88). Muscle training exercises were advocated for correction.

In writing about anterior open bite Cooke (1981) furthered the work of Tulley and identified the signs of "endogenous" tongue thrusts:

- (1) A tendency by the patient to lisp,
- (2) An anterior open bite larger than would be expected with a tongue to lower lip anterior oral seal, and
- (3) Excessive muscular activity around the lips when swallowing.

Garliner (1971) also classified tongue thrust according to the associated malocclusion - "abnormal swallowing pressure against the dentition will create eight types of occlusal problems":

(1) Upper incisors - moved labially; can also move the lower incisor lingually when the tongue is retracted after protruding against the upper incisors.

(2) Full anterior to posterior open bite - molar contact only.

(3) Anterior open bite - the "classic open bite", prevention of the upper and lower incisors from erupting normally.

(4) Bi-maxillary protrusion - labial movement of the upper and lower dentition.

(5) Class III malocclusion: (a) Pseudo-Class III and (b) Skeletal Class III. The tongue contributing to the former by moving the lower teeth labially, and to the latter "by finding free space within the skeletal elongation".

(6) Deep overbite with 1-2mm incomplete overbite present - tongue movements will not allow apposition of lower incisors with upper incisors or palate, hence a small space is present.

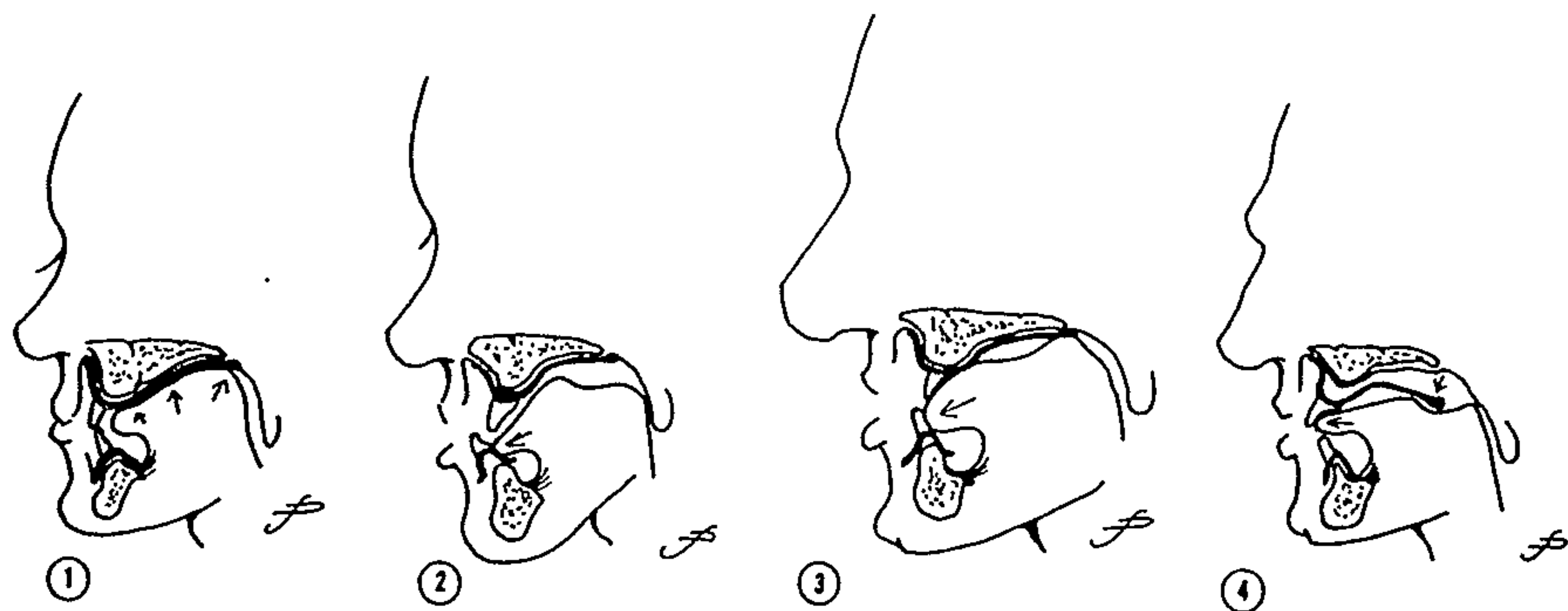


Fig. 1. The normal swallow. The tongue is raised into contact with the palate.
Fig. 2. The dentally traumatic swallow. The tongue is pressed against the mandibular anterior teeth.
Fig. 3. The dentally traumatic swallow. The tongue is placed between the teeth.
Fig. 4. The dentally traumatic swallow. The tongue is pressed against the maxillary anterior teeth.

Fig. 88 (1) Normal swallow - the tongue is raised into contact with the palate.
(2) Dentally traumatic swallow - the tongue is pressed against the mandibular anterior teeth.
(3) Dentally traumatic swallow - the tongue is placed between the teeth.
(4) Dentally traumatic swallow - the tongue is pressed against the maxillary anterior teeth. (Plainfield, 1977)

Type		
Anterior thrust	Anteroposterior discrepancy	1. Incisor thrust (Angle Class I)
		2. Full thrust (Angle Class II, Division 1)
		3. Mandibular thrust (Angle Class III)
		4. Bimaxillary thrust
Lateral thrust	Vertical discrepancy	5. Open bite
		6. Closed bite
		7. Unilateral thrust
		8. Bilateral thrust

Fig. 89 Table: Classification of types of tongue thrust. (Barrett and Hanson, 1978)

(7) Unilateral posterior open bite - "unilateral depression in the molar area", often accompanied by a lateral lisp.

(8) Bilateral posterior open bite - by "molar depression".

Goldberger (1978) identified four types of tongue thrusts:

(1) The tongue is thrust forward in the anterior region while swallowing, "often causing an anterior open bite".

(2) The tongue is thrust not only between the anterior teeth but also between the posterior teeth, "causing a diffuse open bite from the molars on one or both sides".

(3) The tongue is thrust to the side, either unilaterally or bilaterally, "causing a lateral open bite in the buccal segments".

(4) The mouth is opened "as much as an inch", and the tongue is thrust forward between the teeth. Because a deep overbite is seen in which the patient's incisors overlap vertically, this type is sometimes difficult to detect.

The most comprehensive classification has been developed by Barrett and Hanson (1978). The categories used describe "only those patterns of deglutition which result in overt harm to the dental structure".

They identify eight types (Fig. 89) with another eight subtypes, one in each class. Five characteristics are noted: (1) classification of molar occlusion, (2) incisal relationship, (3) status of teeth during swallowing, (4) presence or absence of facial movement or contraction, and (5) action of the tongue (see Figs. 90 to 105).

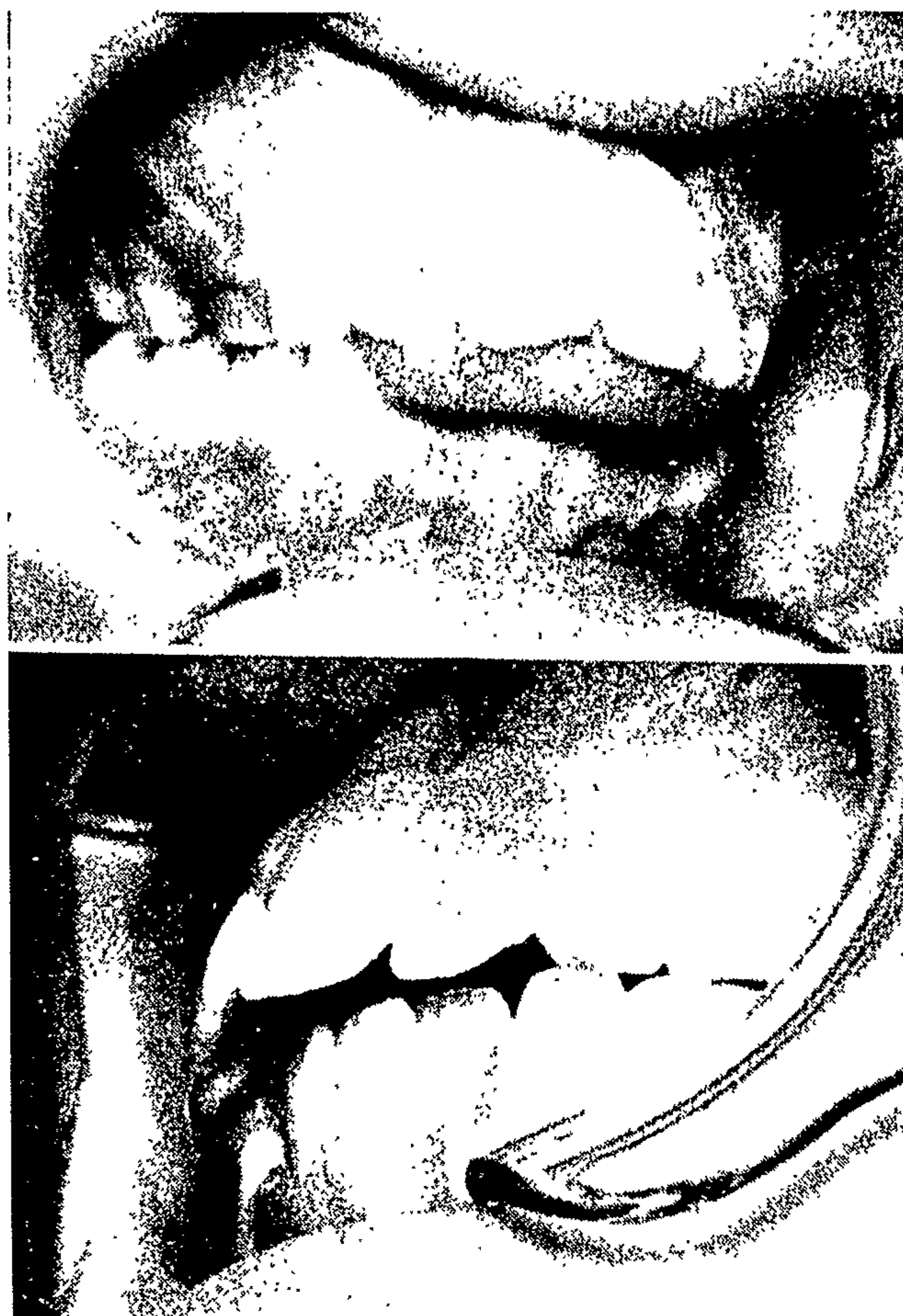


Fig. 90 Type 1: Incisor thrust. (Barrett and Hanson, 1978)



Fig. 91 Subtype/ls./ (Barrett and Hanson, 1978)



Fig. 92 Type 2: Full thrust. (Barrett and Hanson, 1978)



Fig. 93 Subtype /2s/. (Barrett and Hanson, 1978)

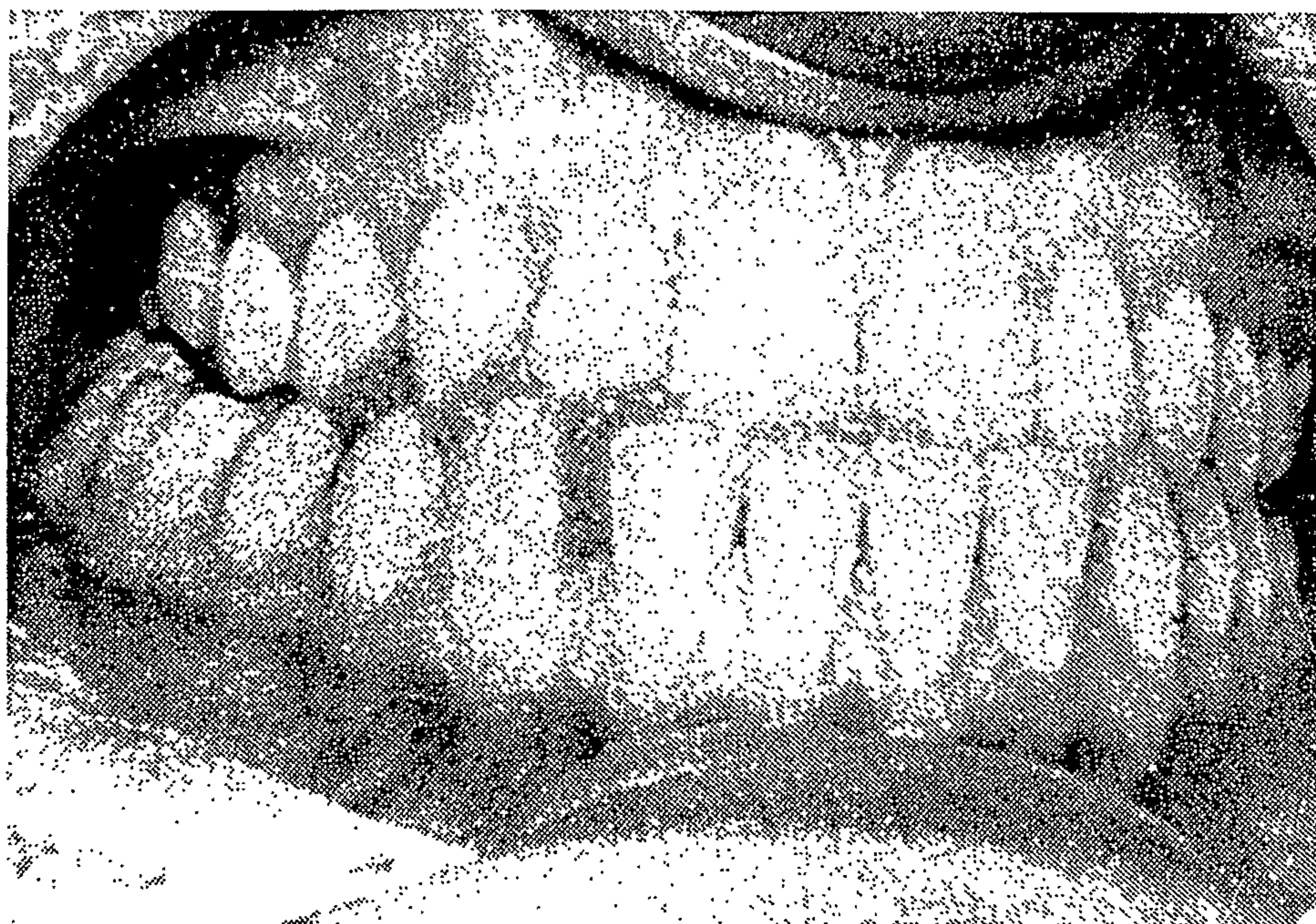


Fig. 94 Type 3: Mandibular thrust. (Barrett and Hanson, 1978)

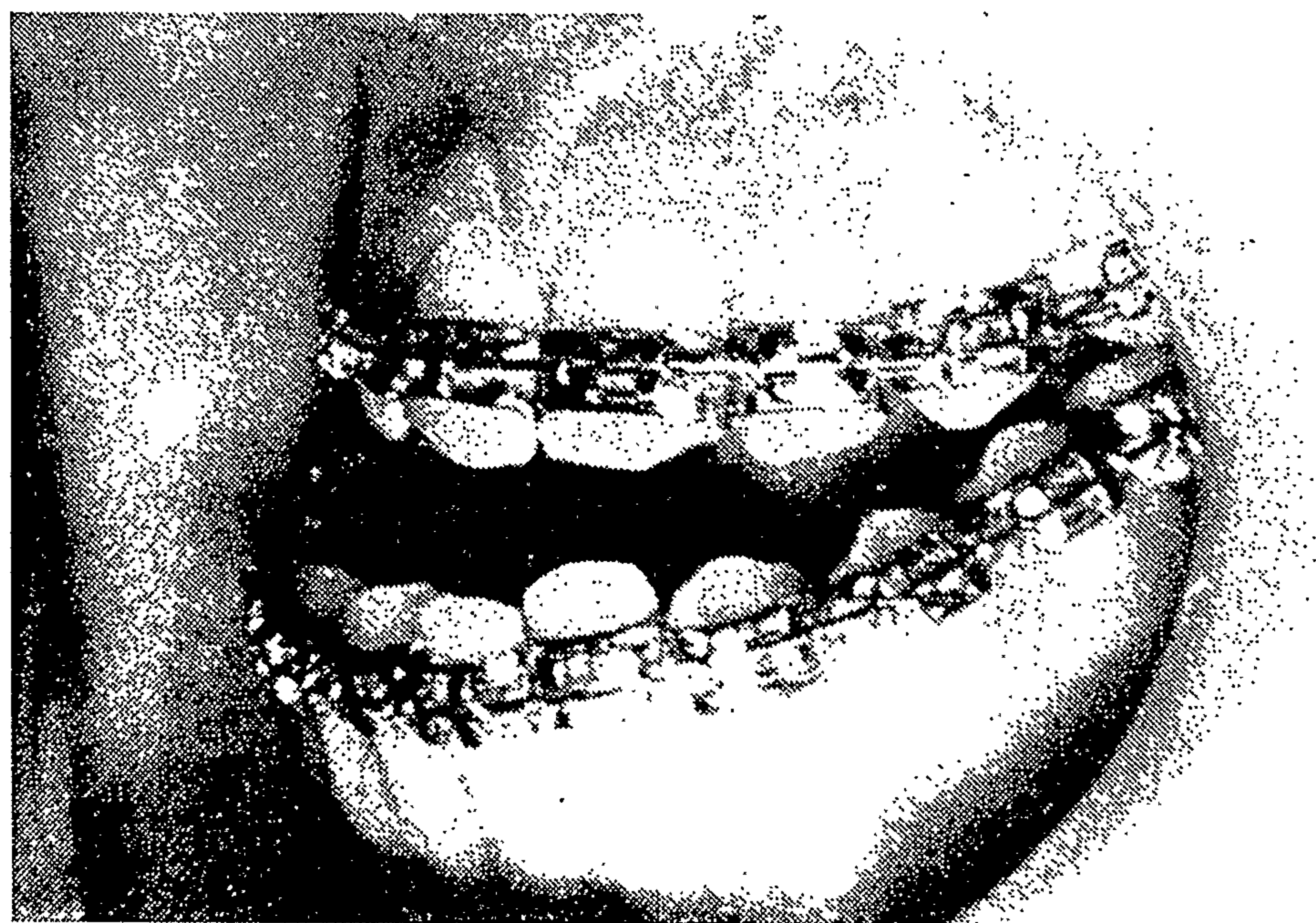


Fig. 95 Subtype /3s/. (Barrett and Hanson, 1978)

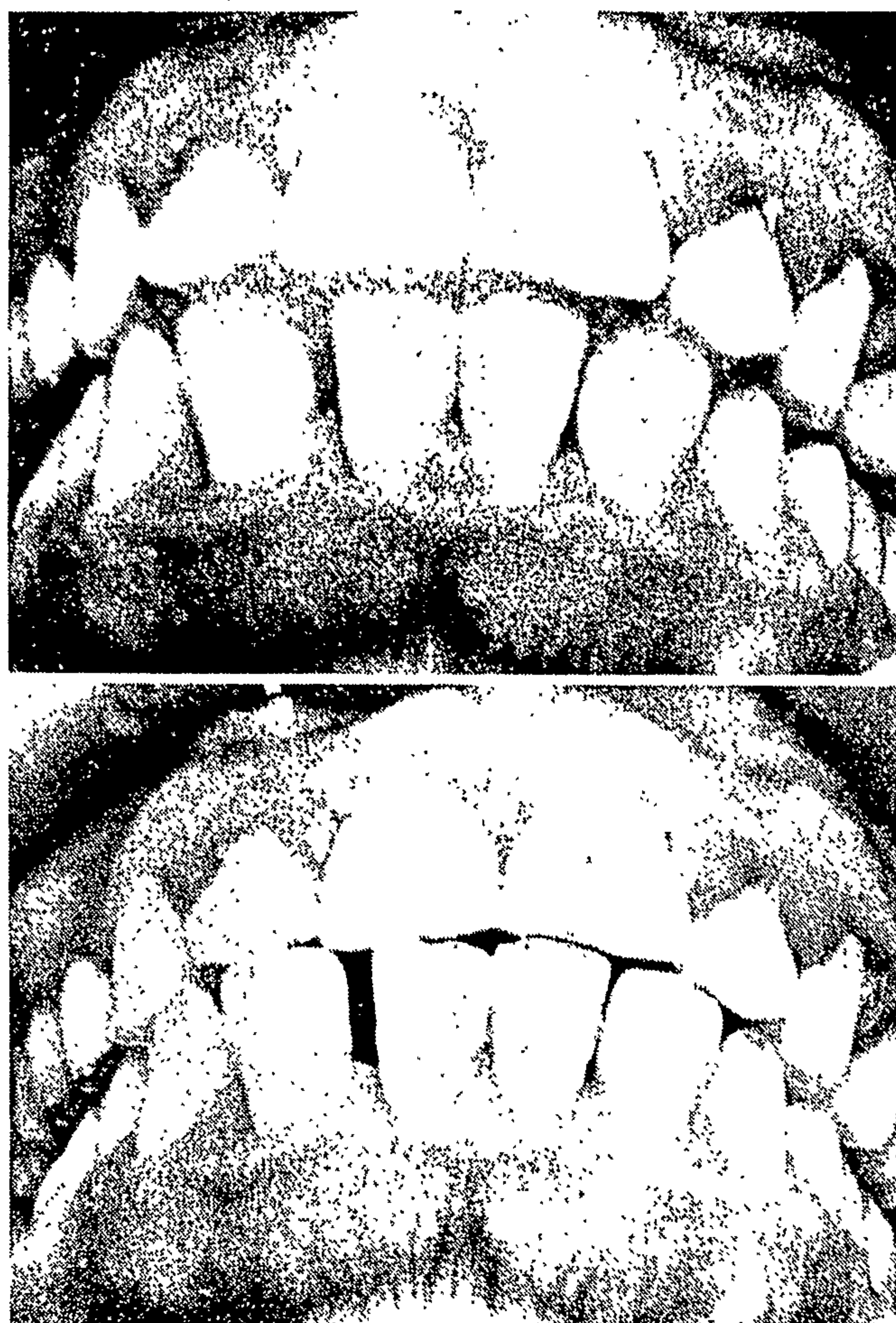


Fig. 96 Type 4: Bimaxillary thrust. (Barrett and Hanson, 1978)



Fig. 97 Subtype /4s/. (Barrett and Hanson, 1978)

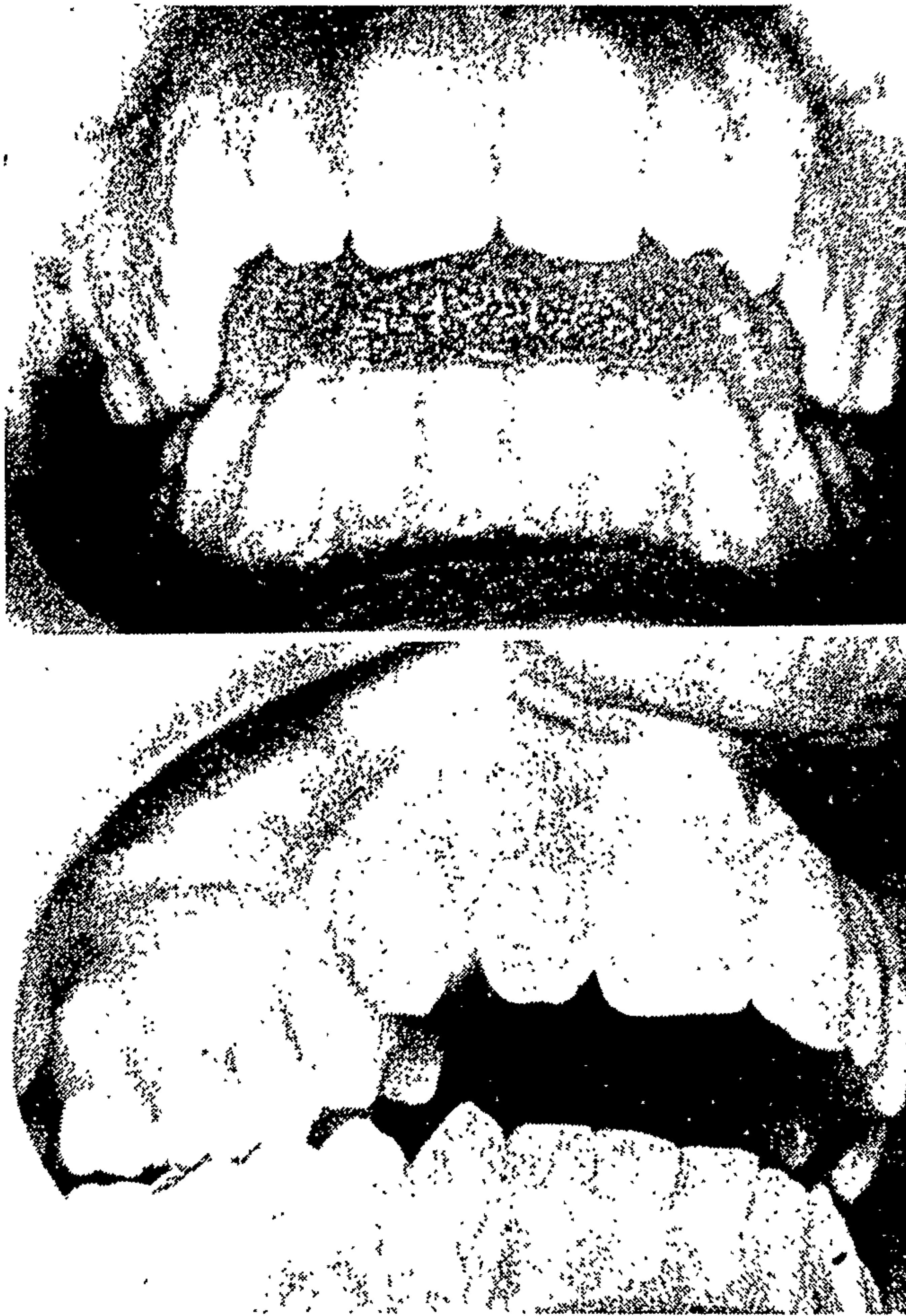


Fig. 98 Type 5: Open bite thrust. (Barrett and Hanson, 1978)

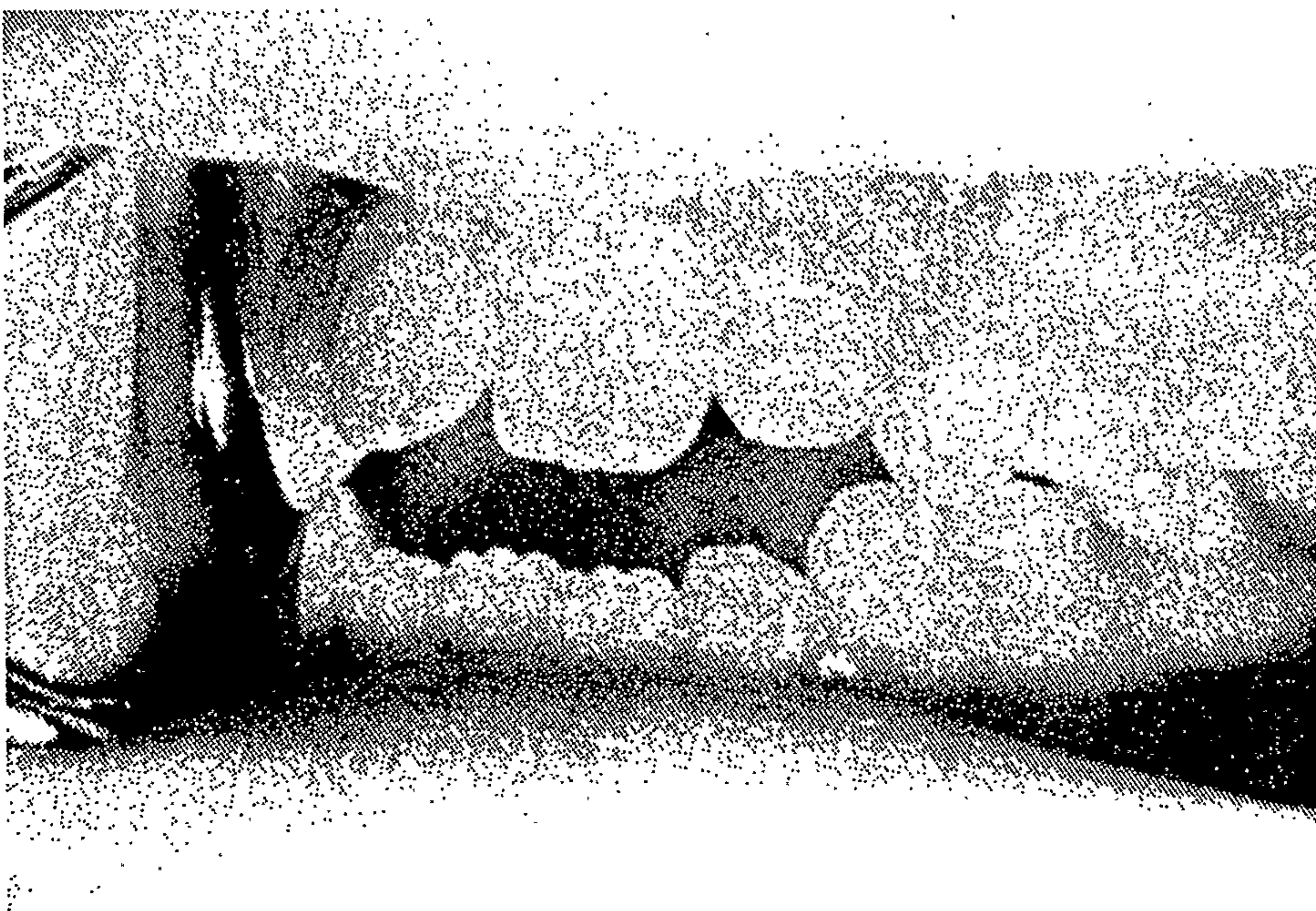


Fig. 99 Subtype /5s/. (Barrett and Hanson, 1978)

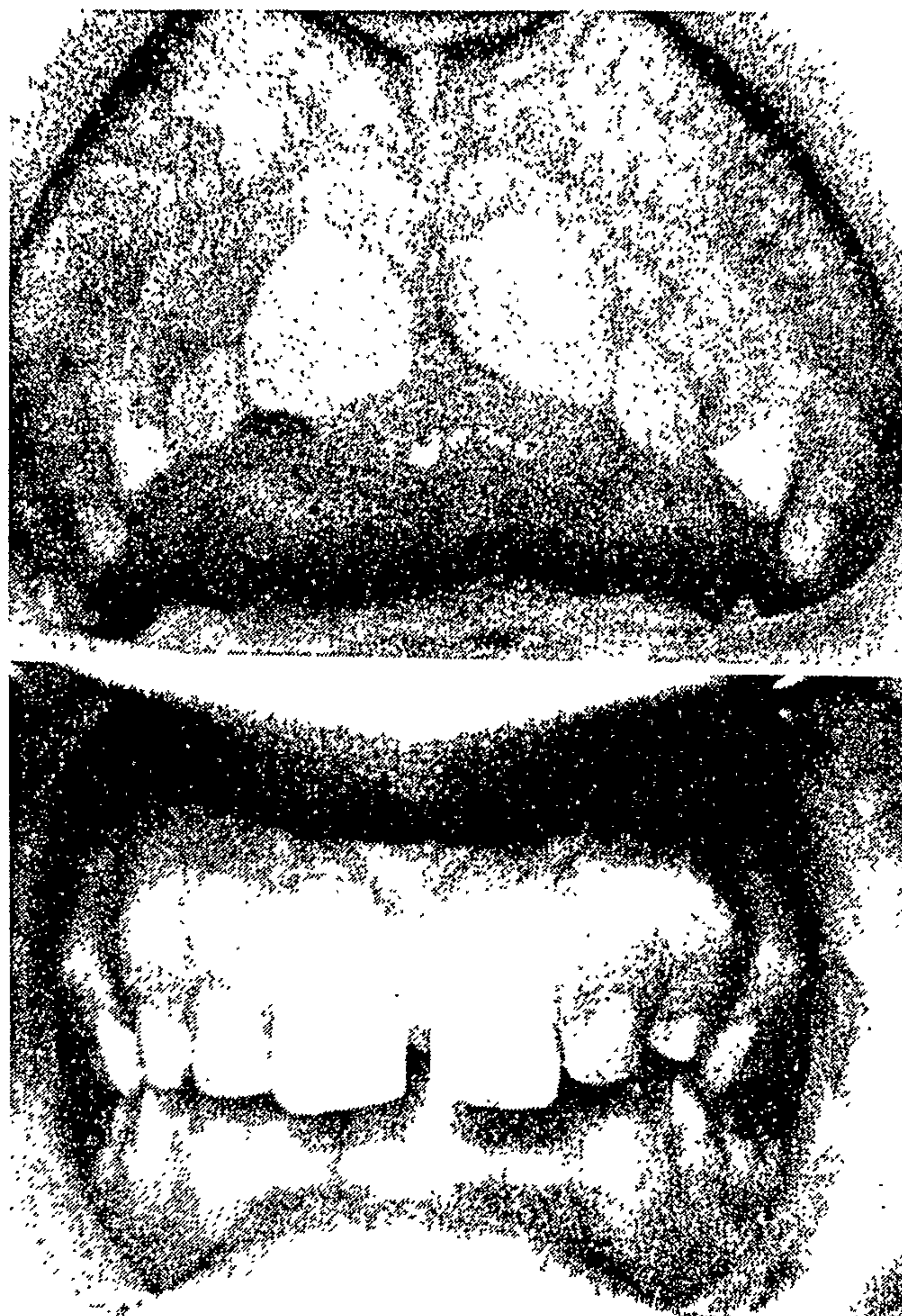


Fig. 100 Type 6: Closed bite thrust. (Barrett and Hanson, 1978)



Fig. 101 Subtype /6s/. (Barrett and Hanson, 1978)

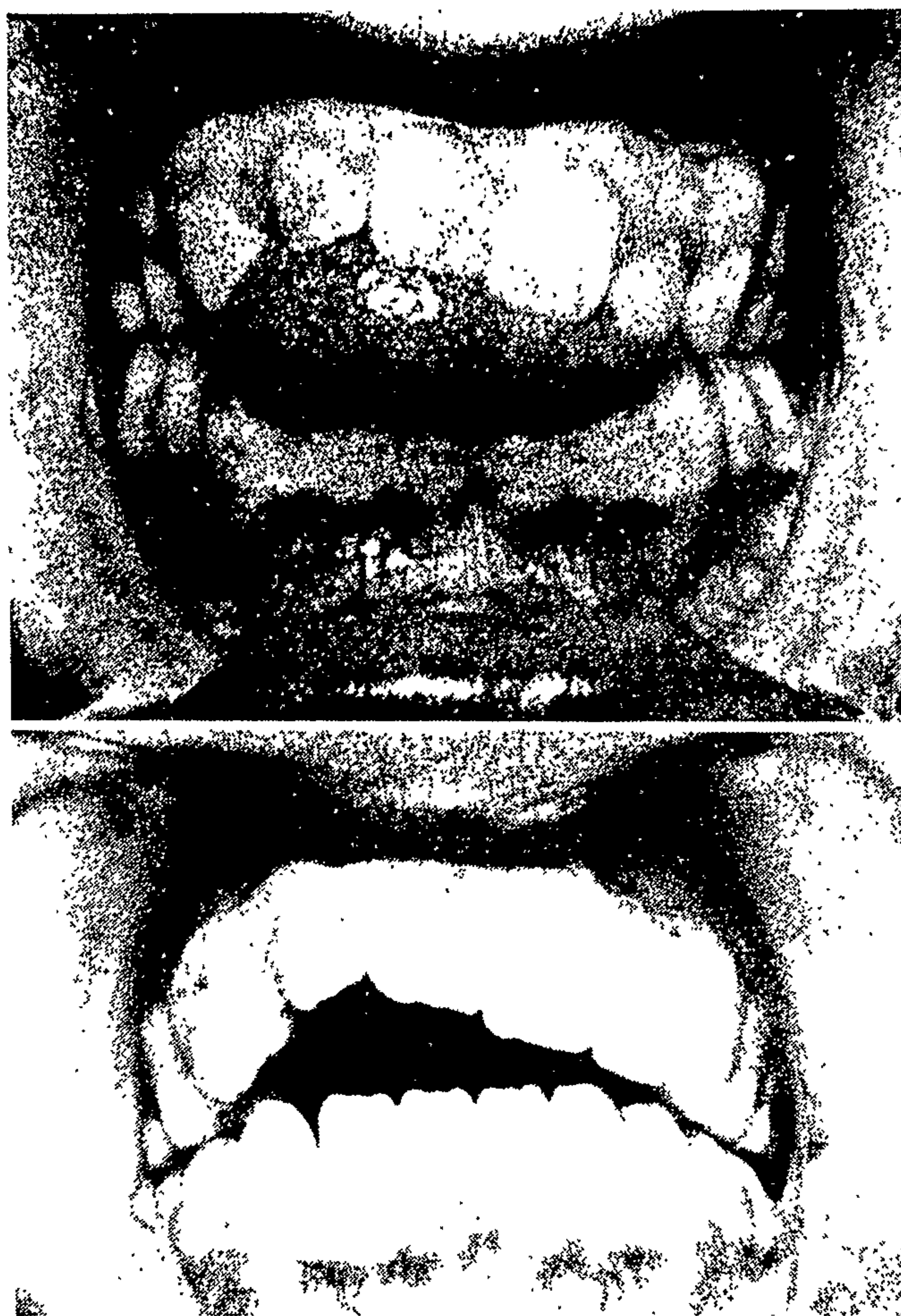


Fig. 102 Type 7: Unilateral thrust. (Barrett and Hanson, 1978)



Fig. 103 Subtype /7s/. (Barrett and Hanson, 1978)



Fig. 104 Type 8: Bilateral thrust. (Barrett and Hanson, 1978)



Fig. 105 Subtype /8s/. (Barrett and Hanson, 1978)

Type 1. Incisor thrust

Occlusion: Class I; may have crossbite.

Incisors: Overjet, lowers moderately retruded.

Teeth: Apart.

Perioral muscles: Usually a generalised constriction of lip and cheek muscles.

Tongue action: Pressure concentrated on the incisors in a wedging action, driving uppers and lowers apart anteroposteriorly.

Subtype /1s/.

Differentiating characteristics: Upper incisors relatively normal; lowers excessively retruded and often supererupted.

Type 2. Full thrust

Occlusion: Class II, Division 1.

Incisors: Marked labioversion of uppers; lowers retroclined and classically in a jumbled but direct line from cuspid to cuspid. Incisal edges contact nothing when molars are occluded.

Teeth: Apart.

Perioral muscles: Hyperactive mentalis; lower lip on lingual surface of upper incisors.

Tongue action: "Dispersing" action, spread between teeth around the dental arch from approximately first molar to first molar, an exaggeration of Type 1.

Subtype /2s/.

Differentiating characteristics: Accompanying anterior open bite, perhaps arising from teeth occluded against tongue and causing infraeruption of all affected teeth.

Type 3. Mandibular thrust

Occlusion: Class III, usually in the absence of true prognathism, a pseudo-Class III. Lower molars usually contained within uppers, may have unilateral crossbite.

Incisors: Uppers relatively normal, may have constricted upper arch; lowers protrusive, may display spacing.

Teeth: Slightly parted, although cusps may overlap slightly.

Perioral muscles: Facial grimace, particular tension in triangularis and upper fibres of orbicularis oris.

Tongue action: Apex thrust against lower incisors or symphysis of mandible.

Subtype /3s/.

Differentiating characteristics: Anterior open bite.

Teeth: Apart.

Perioral muscles: Similar but with strong contraction of buccinator.

Tongue action: Inversion of Type 2s, spread between incisal edges in contact with upper lip.

Type 4. Bimaxillary protrusion

Occlusion: Class I.

Incisors: Both uppers and lowers in labioversion, often some spacing of lowers.

Teeth: Apart only slightly, or closed.
 Perioral muscles: Mild contraction.
 Tongue action: Thrust against lingual margins of upper and lower incisal edges.

Subtype /4s/.

Differentiating characteristics: Class II, Division 1 malocclusion. Often appears to be a basic Type 4 swallowing pattern superimposed on a different dentoskeletal structure.

Type 5. Open bite

Occlusion: Class I.
 Incisors: Normal anteroposterior relation, both uppers and lowers infraerupted, incisal edges parallel in molar occlusion.
 Teeth: Apart, closed only to contact tongue; molars are upright.
 Perioral muscles: Generalised moderate constriction of facial network, especially of mentalis.
 Tongue action: Thrust into contact with lower lip before molars occlude.

Subtype /5s/.

Differentiating characteristics: More circumscribed, constricted.
 Incisors: Incisal edges form a well-defined oval when molars are occluded.
 Teeth: Closed.
 Perioral muscles: Strong circumoral contraction, particularly buccinator, causing constriction of both arches; all molars tipped lingually; usually overdeveloped mentalis.

Type 6. Closed bite

Occlusion: Class I.
 Incisors: Normal relationship or slight mild overjet; both uppers and lowers may be supraerupted.
 Teeth: Apart; great "excursion" of the mandible as it drops to allow tongue protrusion.
 Perioral muscles: Little contraction.
 Tongue action: Flaccid generalised protrusion.

Subtype /6s/.

Differentiating characteristics: Class II, Division 1 malocclusion.
 Incisors: Entire lower arch constricted.
 Tongue action: Spread over lower arch.

Type 7. Unilateral thrust

Occlusion: Class I; may have crossbite on side opposite tongue thrust.
 Incisors: Normal centrals; lateral incisors, cuspids, and first bicuspids on one side only undererupted, display unilateral open bite.
 Teeth: Usually closed.
 Perioral muscles: Strong generalised contraction.
 Tongue action: Thrust at a 45-degree angle toward the involved cuspid. "This is somewhat like a misguided Type 5."

Subtype /7s/.

Differentiating characteristics: Unilateral open bite distal to basic type.

Perioral muscles: Reduced contraction.

Tongue action: Thrust toward involved first or second bicuspid.

Type 8. Bilateral thrust

Occlusion: Class III, may be Class I in younger patients. Bilateral open bite in molar region.

Incisors: Normal relationship or slight retrusion of uppers.

Teeth: Apart; incisors may touch.

Perioral muscles: Little or no contraction.

Tongue action: Spread bilaterally between buccal teeth, often centering at the first molar but may be slightly distal or may extend as far mesially as the cuspids. Tongue tip usually braced against lower incisors in order to execute thrust.

Subtype /8s/.

Differentiating characteristics: Class II, Division 2 malocclusion. Bilateral open bite less pronounced. "Note that in Class II, Division 2, incisors are frequently supraerupted, resulting in anterior closed bite."

Barrett and Hanson point out that tongue thrust may be superimposed on any type of occlusion or may be a major etiological factor, depending on the individual case. Although certain patterns of behaviour are characteristic for each type, they say, the categories are so closely adjacent that some overlapping occurs. It is best to view this system as a continuous spectrum, with slight differences in behaviour sometimes leading to one or another manifestation.

Furthermore, they say that each type may then be examined, noting (a) classification of molar occlusion, (b) incisal relationship, (c) status of teeth during swallowing, (d) presence or absence of facial movements or contraction, and (e) action of the tongue.

In conclusion, they suggest that the historical differences in opinion regarding tongue thrust may well be understood when viewed with this classification in mind. "It may be noted that not one characteristic remains constant throughout the various types."

3.3 Associated Muscular Activity

Most of the muscular activity associated with normal swallowing and tongue thrust posture and swallowing has been covered in previous sections. However, further discussion of the more pertinent aspects will be reviewed with particular reference to the more controversial aspects. From a diagnostic perspective, identification of the various nuances of abnormal or atypical lingual muscular behaviour is not only difficult but, more importantly, necessary for future treatment planning.

From cinefluorographic studies it was concluded that protrusion of the tongue to contact the lips may occur during swallowing in subjects with malocclusion and in those with normal occlusion (Cleall, 1965), and also physiologically i.e. when the permanent incisors are erupting (Milne and Cleall, 1970). In subjects with maxillary overjet, an anterior seal is often obtained by intrusion of the lower lip between upper and lower incisors and protrusion of the tongue, but after correction of incisor occlusion, according to Subtelny (1970), these features may disappear.

Moller (1976) gives a detailed account of the muscle coordination in swallowing. It is characterised, he says, by synergistic activation of the muscles of mastication with systematic differences between pairs of muscles at the onset of activity. The elevators start with intervals of about 50msec. Mylohyoid and digastric muscles are activated simultaneously, in time with the temporal muscle, but the time course of their activity differs. The mylohyoid muscles contribute to tongue movements in the oral phase by stabilising the hyoid bone and contract strongly from the onset. In the digastric muscles, activity is moderate for the first 150msec., and then strong action moves the hyoid bone and larynx forward and upward. The genioglossus and geniohyoid muscles have a similar time dispersal of strong activity. The muscles of the

lips start early in the oral phase, in time with the pterygoid muscles, to establish an anterior seal.

In regard to tooth contact Moller (1976) points out that over 60% of adults and children swallow with regular tooth contact. In accordance with the early onset of activity in the lateral pterygoid muscles, contact is first made with the mandible protruded, followed by a slide into the intercuspal position.

Subjects habitually swallowing without tooth contact, as might be expected, have less activity in their temporal and masseter muscles (25%) than subjects with tooth contact. However, the degree of activity in the masseter muscle is a poor indicator of tooth contact. All other muscles display the same degree of activity whether tooth contact occurs or not.

For lip and tongue coordination Moller (1976) found that lip and tongue activity in subjects with a different relationship between the length of the lips and the anterior height of the alveolar and dental arches point to a common mechanism of control. With sufficient lip length, only slight activity is necessary to establish the anterior seal. Moderate insufficiency is compensated for by increased activity. However, with obvious insufficiency of the lips, the pattern changes drastically: the lips remain passive while the tongue, indicated by the activity of the mylohyoid muscle, acts earlier. Conversely, an extremely late onset of activity in the mylohyoid muscle, and thus in the tongue, requires intense activation of the lips in spite of sufficient lip closure at rest.

In a discussion of Moller's findings Storey (1976) noted, regarding genioglossus activity, that jaw position also has a profound influence on this

muscle's activity, and that the amount of activity varies in direct accordance with the amount of jaw opening. He also stated that changes in tongue protrusive activity is related to changes in the vertical dimension. Storey made note of the mylohyoid activity as an indication of tongue protrusion, saying that he thought it acted more as a stabilising muscle, especially when the teeth are not occluded. Moller found, however, that mylohyoid muscle activity was a good indirect guide to tongue activity since this muscle acts strongly when the tongue is pressed against the palate or protruded.

It was also pointed out that tongue protrusion must be evaluated on the basis of recordings from the intrinsic tongue muscles, although no such recordings were then available.

The aspect of head posture was brought up by Kawamura (1976). His studies had shown that muscle activity varies when swallowing is carried out with different positioning of the neck and head. For example, suprahyoid muscle activity is weak when one swallows tipped up. Moller pointed out that his recordings during swallowing were obtained with the subject sitting, without head rest. Altering head or body position may affect timing, he said, but not the intensity of the activity in the suprahyoid muscles.

In a study of lip activity Moller (1976) found that the degree of primary activity in the lower lip during mastication is related to facial prognathism. In subjects with retrognathism of both jaws the lips are usually sufficient and the anterior seal demands slight activity; with prognathism the lower lip may be taut at rest and chewing requires strong activity. He said that the relation between lip function and facial morphology exemplifies an important feature: the lips adjust the oral cavity to the particular function being performed (mastication, swallowing, speech) and are primarily activated

to produce their own movements. He assumed, therefore, that the adaptive function seems to depend more on recognition of the shape of the supporting hard tissues than on the tension produced.

Barber and Bonus (1975) and others (cited) found that one of the distinguishing characteristics of tongue thrusters was their possession of "flaccid and incompetent circumoral musculature".

The studies of Simpson (1976) have shown that the mechanism of sealing the lips seems to depend on the activity of the mentalis muscle pushing the lower lip upwards.

Frankel (1980a), commenting on the work of Simpson, makes reference to the function of the lips. When, he says, in the presence of an incompetent lip seal, the lips were approximated, not only was an increase in muscular activity of the mentalis recorded but also of the suprahyoid musculature, resulting in a postural change of the tongue anteriorly. Such a postural change of the tongue, he says, has been considered to be a habit in the past and designated as a 'tongue thrust'. Frankel's findings agree with Simpson's. Frankel suggests, therefore, that the activity of the suprahyoid muscles meets the criterion of a "compensatory function" more than a bad habit. When the orbicularis oris is not capable of producing a competent lip seal, other orofacial muscles must operate to compensate for this failure. Thus the activity of the mentalis and suprahyoid muscles must be considered more an auxiliary function.

Ballard (1953) had previously made reference to the mentalis muscle activity in his description of abnormal swallowing. He said the tongue is thrust between the incisor teeth, and usually against the upper incisors and

over the lowers (Class II, Division 1 case). This thrust is balanced by a contraction of the lower lip, as is evidenced most markedly by the contraction of the mentalis muscle. The tip of the tongue labially inclines the upper labial segment, and the contraction of the lower lip against the tongue thrust lingually inclines the lower labial segment. The effect of the abnormal swallow is to produce a degree of increased overbite and/or overjet, the variations being in relation to other factors in the case.

Historically, there have been many studies which have not helped to clarify the distinction between "normal" swallowing and "abnormal" swallowing or posture.

Winders (1958) found that the movement of the tip of the tongue during swallowing appears to be determined by the position of the mandibular incisor teeth. He also found that the buccal and labial musculature does not contract during swallowing unless there is an anterior open bite or lack of anterior overbite with accompanying anteroposterior skeletal dysplasia; that a tongue thrust during swallowing can be the cause, not the result of the anterior opening; and that the tip of the tongue is placed behind the lingual surfaces of the maxillary central incisors during the act of swallowing, and not brought into contact with the central incisors in normal occlusions or malocclusions with deep overbite.

Rogers (1961) found that a high number of school children with deep overbites demonstrated tongue thrusts while swallowing (68.9% of normal population sample, 56.3% of orthodontic patients), and that "facial grimace" appeared in normal swallowers.

Rosenblum (1963) found orofacial activity in 65.3% of his sample of

subjects with "excellent dental occlusions". He studied modiolus and mentalis activity and concluded, "the findings of this study indicate that, in the age range of thirteen to twenty years, activity of the orofacial musculature during deglutition may not necessarily be an indication of 'abnormal swallowing'".

Long (1963) found that although minor variations were numerous, tongue thrust swallowing appeared to be identical to normal swallowing except for the placement of the anterior portion of the tongue. His study found (1) many tongue thrusters did not grimace and many subjects who grimaced had no tongue thrust; (2) many tongue thrusters swallowed with their teeth in occlusion while a few classified as "normal" swallowed with their teeth apart; (3) glossopalatal contact was identical for both groups and was one of the most consistent characteristics of swallowing in both groups.

Hedges, McLean, and Thompson, Jr. (1965) found, in their study of children with "clinically excellent occlusions" and other supranormal features (mentioned previously), that teeth apart swallows were common. The differences between those with, and those without, teeth-together swallows were only slight.

Cleall (1965) found that the tongue tip at rest was lower in the tongue thrusters he studied. As a group, tongue thrusters were not found to posture the tongue tip abnormally further forward in relation to the lower incisors. As individuals, 16% of this group rested with the tongue tip anterior to the lower incisors. This observation was never made in either the normal or Class II samples studied. The tongue tip, however, was found to move further forward during swallowing in the tongue thrust group than in the other two groups. This finding was consistent (100% of subjects), and validated, he said, the original clinical selection of the group.

Lip separation, also, was greater in the tongue thrust group; this was a consistent finding both at rest and in function.

Few clear-cut differences were observed in the posterior region of the mouth, but at rest the hyoid bone was found to be more posterior in the tongue thrust group when compared to normal, and lower than in the Class II group. In function, this bone was also found to be situated in a more posterior position than normal.

Cleall, Alexander, and McIntyre (1966) observed no conclusive differences in the head posture of subjects with normal occlusion and those with Class II malocclusion or those with anterior tongue thrust. Only slight variations were observed.

Neff and Kydd (1966) found that their study on open bite subjects showed that the tooth apart swallow cannot be used to describe all tongue thrusters as the open bite tongue thrusters habitually occluded their jaws upon swallowing.

The study of Peat (1968) in which he found two postural positions of the tongue for each individual (mentioned previously), seems to indicate that it is not abnormal for the tongue to contact the teeth either while resting or during swallowing.

Moyers (1973) described normal and abnormal tongue posture (Fig.105a). During "mandibular posture", the dorsum touches the palate lightly, whereas the tongue tip normally is at rest in the lingual fossae or at the crevices of the mandibular incisors. Abnormal positions found are, (1) the tip atop the lower incisors, producing an open bite, or (2) a retracted or "cocked" tongue,

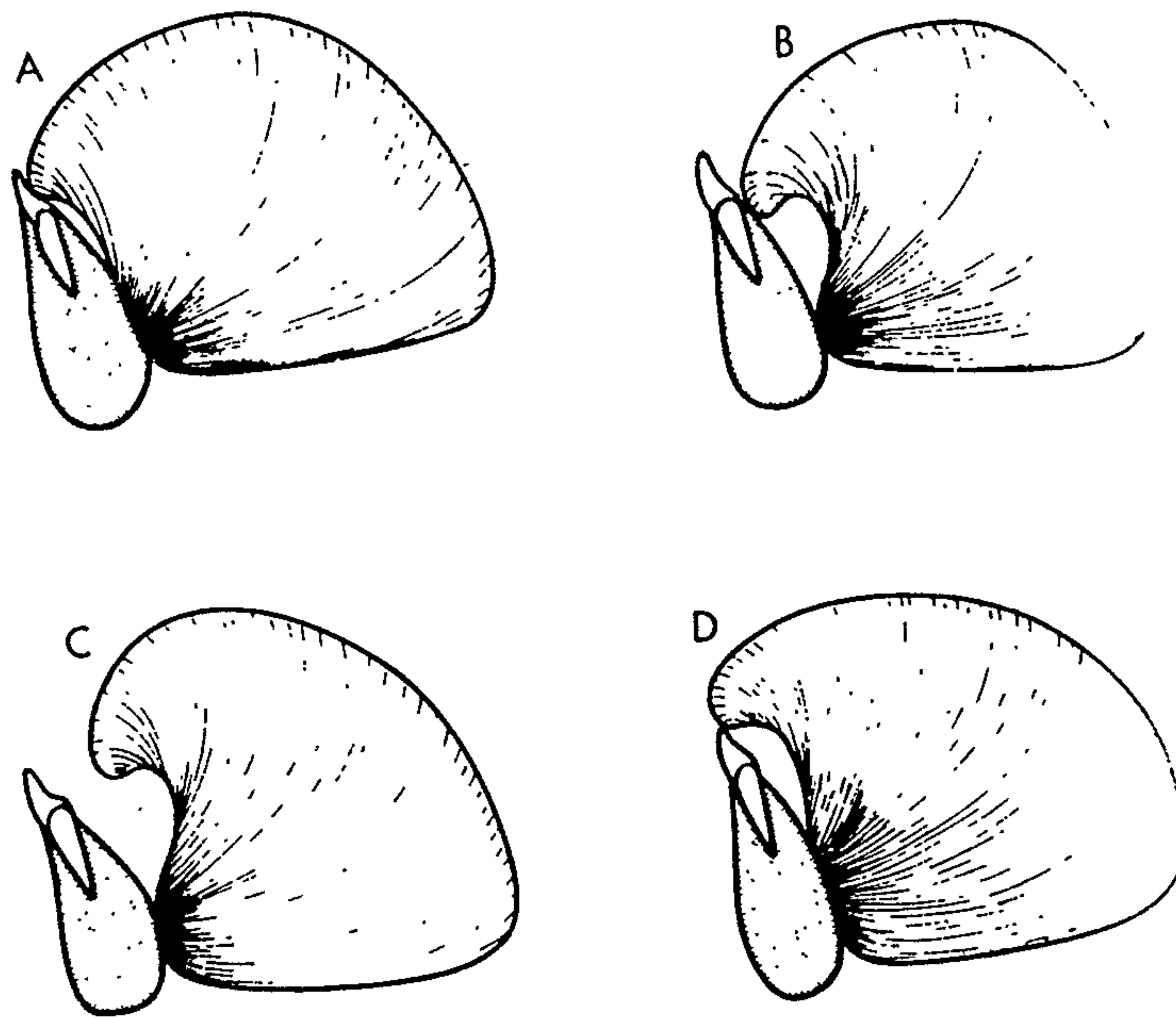


Fig. 105a Variations in tongue posture. A and B, variations in normal tongue posture. C, retracted tongue posture. D, the retained infantile tongue posture. (Moyers, 1973)

which does not cause a malocclusion.

Hanson, Hilton, Barnard, and Case (1970) reported that; (1) a thorough, meaningful study of swallowing behaviour should include the swallowing of solids as well as liquids; (2) in agreement with their earlier findings (Hanson, Barnard, and Case, 1969) "certain diagnostic and descriptive criteria associated by many writers with tongue-thrust were not consistently confirmed in this study of pre-school children". These inconsistencies were most evident in discrepancies of response between liquid and solid swallows; (3) only four factors were significantly related to the type of swallow:

(a) Tongue thrusters displayed more consistency in the extent of hyoid movement during the swallowing of solids, favouring moderate or minimal movement over marked movement.

(b) In both tongue thrusters and non-thrusters there was a significant tendency for the hyoid to be elevated in an arc for solid swallows and diagonally for liquid swallows.

(c) Tongue thrusters were more consistent in the amount of lip movement during swallowing, favouring moderate movement over either extreme of response. Marked tongue thrusters tended to move the lips to a marked degree.

(d) It was significant that tongue thrusters generally did not occlude the molars during swallowing of liquids.

They concluded that research at that stage indicated that the most consistently reliable manner of determining the presence and type of tongue thrust was by direct observation (described later) of tongue movement during swallowing.

Ricketts (1968) in his discussion on "respiratory obstruction syndrome" described how the angle or drape of the soft palate could affect tongue posture. In some instances (described) the soft palate tends to be held downward in the interest of maintaining the nasal airway, and the tongue would conditionally acquire a forward or downward posture in the mouth as a result of the functional demands of the soft palate. This is even more marked when the nasopharynx is filled with adenoid tissue, discussed later - "there tended to be a strong relationship between adenoidal tissue or tonsillar tissue and tongue position".

Goda (1968) observed that non-tongue-thrusters depend heavily on the tip or anterior portion of the tongue to form the tight seal leading to creation of a partial vacuum, negative pressure, and subsequent easy swallowing. The interdental tongue placement by tongue thrusters, however, makes it virtually impossible for the tongue to assist in the creation of the seal. The force of the tongue is directed against the upper teeth or between the upper and lower teeth, resulting in a weak, almost nonexistent seal and can cause, in time, poor occlusal relationships.

Tongue thrusters, he said, have to rely on other muscles in the creation of the seal. The lips need to be tightly occluded, or the tongue, because of its thrust, can force them apart. The facial muscles of expression also need to become more tense to help in the creation of the tight seal and to counteract the thrust of the tongue. If the tongue placement were changed so that its strong thrust could assist and not hinder swallowing, the facial muscles of expression would not have to work as hard. Furthermore, the changed position where the tongue might be able to form its tight seal in order to assist swallowing would have to be away from the teeth so that its thrust would not be detrimental to the growth of the teeth.

Proffit, McGlone, and Barrett (1975), after studying tongue tip movements during swallowing in Australian Aboriginals, found that tongue pressure against the lower incisors occurs with equal magnitude and at the same time in the swallowing pattern. Elevation of the tongue to contact the maxillary alveolar ridge does not lift it away from the mandibular arch. In addition, the approximately equal duration of the pressure patterns for lips and tongue indicated that both act at the same speed. It appears to be incorrect, they concluded, to think of the lips as being slower than the tongue during swallowing.

They also found some differences in lip activity depending on the material being swallowed, as mentioned previously. A very small lip pressure was found during swallowing of water compared to swallowing of saliva. In swallowing saliva, pursing of the lips occurred. This did not happen for water. Tongue movements also are different for swallows of water and saliva. Nove, as quoted by Dunn (1964), described how food tended to be gulped, "as it is not retained in the mouth as well by the tongue with the teeth apart". This is often accompanied by a series of pre-swallowing movements such as "a forward thrust of the mandible and neck or a flexion of the neck" together with the marked circumoral muscle contraction mentioned previously.

Barrett and Hanson (1978) stressed the vast variety of entities involved in swallowing behaviour and described "abnormal swallowing" in terms of general physiology, saying that as normal swallowing is viewed in a general way, "so deviant swallowing must be granted leeway for multitudinous variations" (Fig. 106).

Following a description of the pattern of mastication observed in tongue thrusters, a feature of which is the incompetence of the lips and the

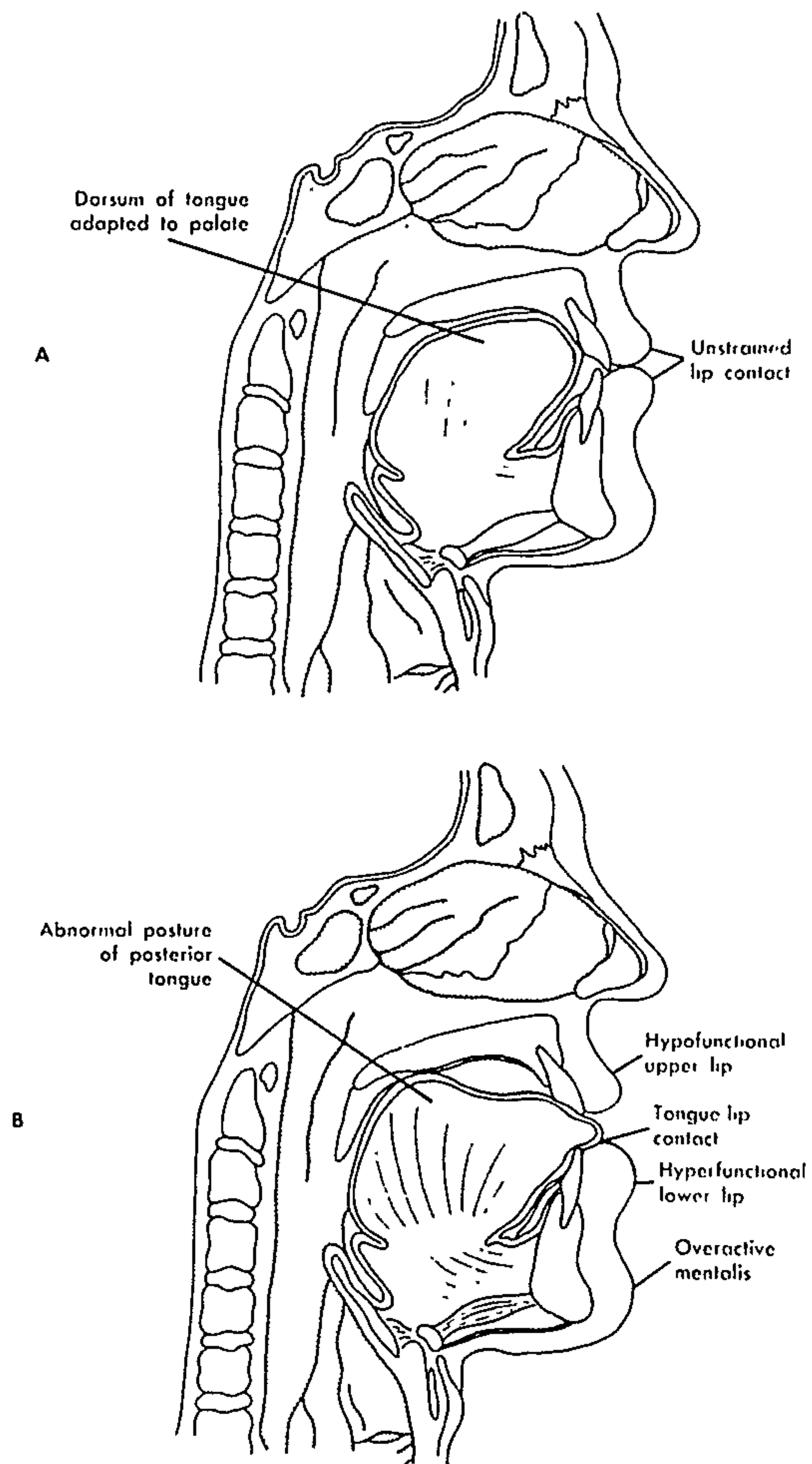


Fig. 106 Tongue and lip postures in deglutition.
A, normal swallow.
B, abnormal swallow.

(Barrett and Hanson, 1978)

lack of fine motor control while manipulating the bolus, a detailed description of the oral stage of 'abnormal' swallowing is given. They stress that all the factors presented are not necessarily present in each swallowing act of every subject. Any one of them may be absent, depending on individual influences. Some of the features are:

(1) Inefficient bolus formation, which often results in facial movements (presumably the "facial grimace" of Rogers (1961), occurring before the act of swallowing;

(2) Physical displacement of the tongue, the actual 'tongue thrust', forcing the bolus distally by sheer muscle force, primarily through excessive contraction of a probable combination of mylohyoid, geniohyoid, styloglossus, and genioglossus muscles. The other occlusal and muscle variables are also described;

(3) Palato-lingual approximation is described, as well as the lateral movements of the posterior tongue;

(4) Veloglossal muscle action, and dysfunction; and

(5) Tongue and lower lip contact. The "conditioned reflex" of this contact in some patients is described. The exception to this contact is also described, the "functional Class III" type of malocclusion.

In reference to the second and third stages of swallowing, these authors note that nothing abnormal has been demonstrated to occur in these phases. In conclusion they stress again the variation of function observed, hoping, though, to have shown a separation between "anomalous" and "acceptable" function.

Finally, Pierce (1978) stressed the importance of diagnostic criteria used to detect tongue thrust. She points out that many of the problems that have beset the investigation of swallowing behaviour are the result of the

different criteria used. Some writers have relied strictly upon observed protrusion of the tongue during swallowing, while others have contended that the entire "syndrome" must be present. The movement of the tongue itself appears to be the only true indicator of a thrust pattern. One thing is certain, she adds, that there is great variability in swallowing behaviour among normal swallows as well as among those clinically diagnosed as deviate swallows.

In conclusion, she comments: "The question of definition and variability of behaviour should not negate the concept of a 'right' and 'wrong' way to swallow. Consider the many different definitions and descriptions of stuttering. Certainly no two stutterers stutter alike; yet we can all recognise stuttering when we encounter it. We don't deny its existence just because it manifests itself differently in each patient. The same flexibility must be applied to the diagnosis and treatment of oral myofunctional disorders". Meaning that tongue thrust can be viewed in this way, since "oral myofunctional disorders" describes the overall spectrum of oral muscle disorders, of which the multifaceted tongue thrust manifestations are the major part (Hanson, 1979a).

3.4 Incidence and Maturation Factors

Research studies have produced conflicting data on the incidence of tongue thrust. Any mention of incidence should be accompanied by some definition and method of determining the tongue thrust; unfortunately this is rarely the case.

As mentioned previously, tongue thrust can be a normal developmental process or it can be a manifestation of deviant oral behaviour. The distinction between the two has been the source of much controversy and still remains the clinician's *bête noir*. For, during the process of growth and maturation, the tongue-thrusting of the infant gives way to the mature swallow of the adult. Unfortunately, this metamorphosis of posture and swallowing pattern can occur over a very wide time frame. Therefore, one would expect a gradual decrease in incidence with an increase in age. This is reflected in most studies, however there is much conflicting data, for various age groups have been examined using various diagnostic criteria.

Another factor in this has been the fact that nearly all studies have been cross-sectional. Cole and Cole (1980) took the average results of sixteen cross-sectional studies conducted over the previous twenty years (Fig.107). This clearly showed the trend in the decrease of tongue thrust with age. What is of significance is that for "adults" there are still 10-20% who are tongue-thrusting. Whether treatment is really indicated for these people remains unsure, and whether, if treatment is indicated, they could have been detected at an earlier age is of importance. The criteria associated with the retention of tongue thrust will be reviewed in a later section; an overview and examination of past studies and the reasons for the conflicting results is now presented.

Incidence of Tongue-Thrust Swallowing	
Age	Incidence (%)
Newborn	95-100
3	80-85
5	65-75
6	55-65
9	40-45
10	30-35
16-18	25-30
Adult	10-25

Fig. 107 Table: Tongue thrust incidence. (Cole and Cole, 1980)

Rix (1946) studied 93 children between the ages of 7 to 12 years. Twenty seven swallowed with teeth apart, and 81% of this group had "deviate dentition".

Rogers (1961) compared a group of orthodontic patients with a group of children from public schools, some of whom had orthodontic problems. The incidence of tongue thrust was high in both groups - 56.9% in the school children and 62.8% in the patients. It was particularly high among subjects with deep overbite (79.7% and 62.8% in the respective groups). Subjects with open bites demonstrated a great tendency toward tongue thrust. Among the school children with open bite the incidence was 98.2%, and 92.8% of the orthodontic patients with open bite were tongue thrusters.

Fletcher, Casteel, and Bradley (1961) studied 1,615 school children aged 6 to 18 years. This cross-sectional study showed that over 50% of the children 6 to 7 years of age thrust their tongues, while less than 25% of the 16 to 18 year olds showed tongue-thrusting. The criterion of abnormal swallow was based on the presence of all three of the swallowing signs: (a) no palpable contraction of the masseter muscles during swallowing; (b) extreme difficulty in swallowing when the labial seal was broken; and (c) protrusion of the tongue between the edges of the incisor teeth.

Ward, Malone, Jann, and Jann (1961) determined that approximately 75% of early primary school children exhibited "abnormal swallowing".

Werlich (1962) studied 640 school children and found that 30.4% were tongue-thrusters overall. The criteria used are not clear. However, it is noted that he actively parted the lips with a tongue depressor prior to swallows.

Andersen (1963) observed 59 school students aged 6, 11, and 17 years. He reported tongue thrust incidences of 21.3%, 14.6%, and 9.0% respectively. Only those children with an anterior open bite were diagnosed as tongue-thrusters. As with Fletcher (1961) tongue thrust was termed a syndrome.

Bell and Hale (1963) established a tongue thrust incidence of 80% among 5 and 6 year olds.

Tulley (1964) observed 1,500 children of 11-plus years. He reported only 2.7% to have tongue thrust and malocclusion, for the "more pronounced type of tongue thrust" (Tulley, 1969). Only 1.35% needed expert orthodontic care, being "extremely" difficult cases. Unfortunately, Tulley's figures become unreliable as they appear to change with succeeding articles (Tulley, 1964; Tulley, 1969; Tulley, 1980). It appears that the 1.35% group of "extremely" difficult cases were again divided in half. This time these cases (0.65%) were described as having a "complex problem of tongue behaviour", "accompanied by a very adverse skeletal pattern", which has only tended to confuse the issue and enhance the "chicken and the egg" dilemma. Tulley described treatment for the 1.35% group as being "extremely" difficult, and for the 0.65% group as being "very unfavourable for treatment", and expressed virtually no hope for their treatment. The diagnostic criteria used for the figure of 2.7% were not explained.

Lewis and Counihan (1965) found 97% of 294 newborn infants to be exhibiting a tongue thrust swallowing pattern.

In 1966, Hanson and associates began the first longitudinal study of tongue thrust behaviour. In a series of articles (Hanson, Barnard, and Case, 1969; Hanson, Barnard, and Case, 1970; Hanson, Hilton, Barnard, and Case,

1970; Hanson and Cohen, 1973; Hanson and Hanson, 1973; Hanson and Andrianopoulos, 1982) they explained how the study evolved. Initially 225 randomly selected children were seen, ranging from $4\frac{1}{2}$ -5 years, the mean age was 4 years 9 months. These patients were seen again after four years, then after another four years, then again after another six years. Tongue thrust was defined as a condition in which the tongue makes contact with any teeth anterior to the molars while swallowing. This definition was further broken down into a conservative definition in which the tongue must protrude between the upper and lower teeth during the swallows of at least two of three media: solids, liquids, and saliva; and a liberal definition in which the tongue makes contact with the anterior teeth to any degree.

Their results for the conservative definition at ages 4yrs 9mths, 8yrs 2mths, 12yrs, and 18yrs were 57.9%, 35.0%, 38.9%, and 42.6% respectively. These results as well as the results of three other studies are seen in Fig.(108). As expected in the initial period to 8 years there was a decline in incidence. However, after that age the incidence increased slightly and stayed that way until age 18 at the conclusion of the study. On this evidence it was concluded that although the incidence of tongue thrust declines initially, it does not seem to decline through adolescence. Another aspect that was found was that some subjects used the tongue in a normal manner before adolescence but developed a thrusting pattern at some time during adolescence. Many more aspects were also covered in this study.

Proffit (1972) (mentioned previously) also studied children with tongue thrust, and although not a true incidence study, he concluded it reflected the belief that there exists a transitional stage in maturation when the tongue-thrusting pattern changes to a normal mature pattern. This happened gradually, he said, with periods of remission. He also suggested that a period

FOUR INCIDENCE STUDIES OF TONGUE THRUST

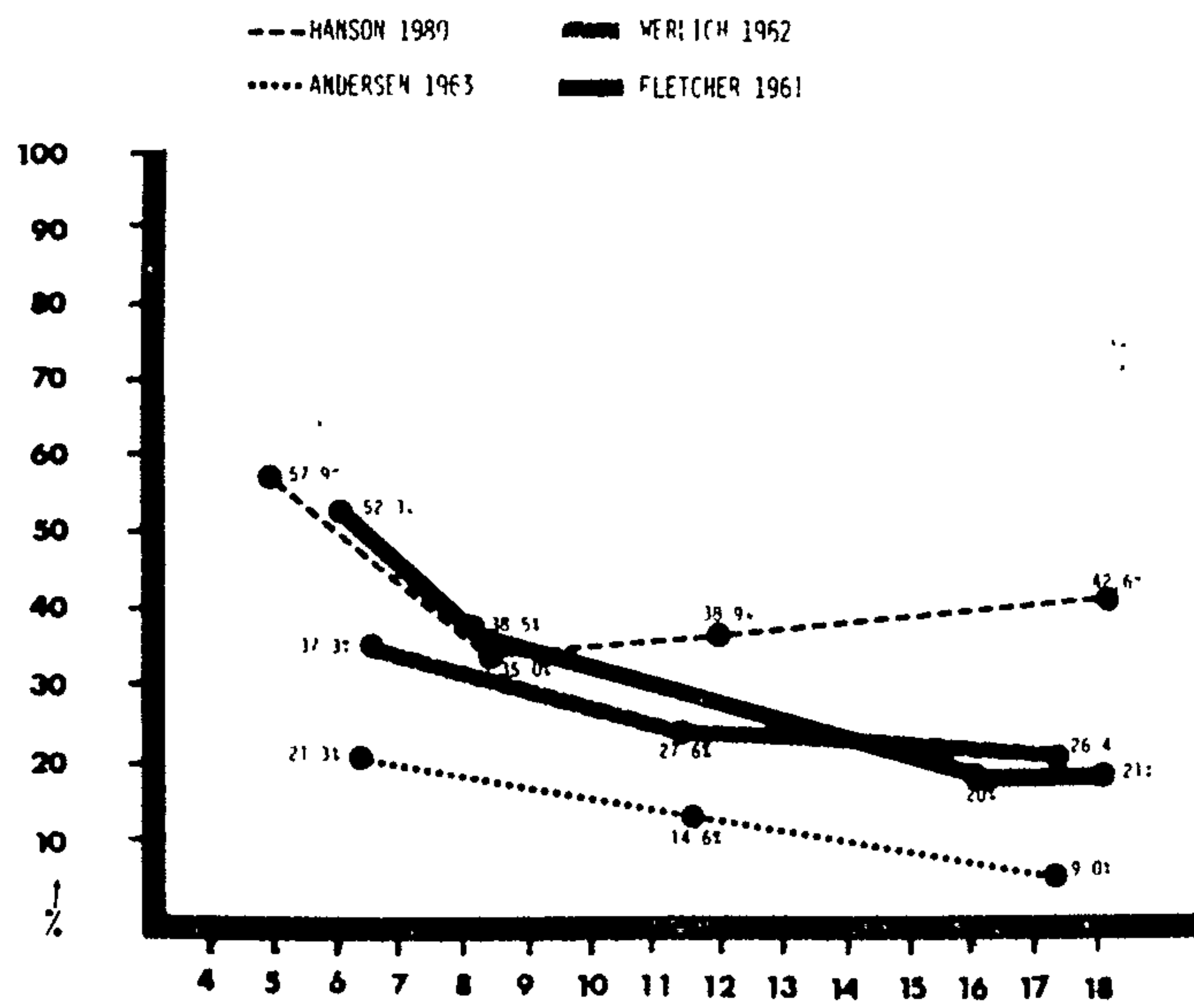


Fig. 108 Tongue thrust: four incidence studies.
(Hanson and Andrianopoulos, 1982)

of accommodation to contain the tongue follows transition. He said this usually happened by the tenth year and frequently occurred much sooner.

The incidence studies seem to indicate that there is a general decline of tongue-thrusting throughout the early years until adolescence, as would be expected in a normal maturation process. Andersen expressed the belief that the decrease is in the order of 1% per year. It still seems unusual that this progression should happen over such a long time, i.e. from 2 to 12 years. Obviously other factors must come into play to influence the retention of the tongue thrusting pattern. This is further exemplified by the findings of Hanson and Andrianopoulos (1982) during the adolescent phase. There seems to be a slight increase in the incidence, when these other factors (such as naso-respiratory disorders) take a greater role as the normal decrease in tongue-thrusting comes to a head.

These studies also seem to indicate that if a child has not developed a normal swallowing pattern by about age ten, then the chances of him/her doing so in subsequent years become less and less. What is it that will determine whether the tongue thrust pattern will persist or not? An examination of other factors involved is necessary. The etiological factors and the factors associated with the retention or perpetuation need to be identified.

3.5 Etiology

According to Brauer and Holt (1965) the etiology of tongue thrust is obscure and the determination of all the etiological factors in any one case is difficult, if not impossible. As Pierce (1978) pointed out, trying to find the cause of a developmental problem has a particular difficulty in that tongue thrust is normal for some age groups and abnormal for others, and we are not sure just when the abnormal pattern can definitely be classed as abnormal. She likens it to rhythm patterns in speech which are considered normal within certain age groups but not so for later age groups.

Unfortunately, we do not have a developmental scale for tongue thrust. We cannot take a patient's stage of development in swallowing and compare it to a set of established norms so that remedial action can be taken if indicated. The reason for this could be in the nature of the contributing factors associated with tongue thrust; for want of a better word - 'etiologies'. We must relate these associated factors, which may not all be contributing, to determine why some children do not develop a normal postural or swallowing pattern along a continuum of maturation.

A review of the literature reveals a plethora of such factors. Most can be listed as:

- . Muscular habit patterns developed in infancy as the result of improper bottle feeding procedures.
- . Inflamed or hyperplastic tonsils and/or adenoids.
- . Mouth breathing.
- . Abnormally constricted oropharyngeal area.
- . Digit sucking and nail biting.
- . Ankyloglossia.
- . Macroglossia.

- . Tongue sucking and other tongue habits.
- . Allergies.
- . Brain injury.
- . Anaesthetic throat.
- . Genetic influences: among a complexity of factors are some of the above, also - a high or narrow palatal arch; restricted nasal passageway due to small nares or a deviated septum; hypertonus of the orofacial musculature; and an imbalance between the number or size of teeth and oral cavity.
- . Open spaces during the mixed dentition.
- . Primary failure of eruption of the dentition.
- . Anterior or posterior open bite; skeletal, dental, iatrogenic, or pathological.
- . Oligodontia.
- . Inherited developmental abnormalities; cleidocranial dysostosis, Down syndrome, cretinism.
- . Soft diet.
- . Psychological arrest.
- . Orthodontic treatment.
- . Oral trauma.
- . Sleeping habits.
- . Oral sensory deficiency.
- . Painful gingival tissue or teeth, keeping the teeth from closing or causing the tongue to be held forward.
- . Neurological disturbances, such as hypersensitive palate; disruption in the tactile sensory control and coordination of swallowing; gross neuromuscular deficiency, which includes a tongue thrusting movement as part of a general extensor thrust pattern; and moderate motor disability and loss of precision in oral function.

- . Psychopathology - tongue thrust as an inappropriate attempt to compete in an aggressive sense and as a manifestation of unresolved oedipal conflicts.
- . Pharyngeal pouches.
- . Developmental impairment - the tongue may not lose its ability to come forward, as in suckling.
- . Premature loss of deciduous teeth.

Clearly a detailed discussion of each is not practicable. Many of these factors will be dealt with in following sections. Some of these factors are now considered of little significance in the etiology of tongue thrust, e.g. bottle feeding. Until recently, much credence was given to the theory that improper methods of bottle feeding (long teat) of infants resulted in tongue thrust. Straub (1951, 1960, 1961, 1962) brought this association to a head in the early '60's after his research on patients he had seen in his practice. However, research since (Hanson and Cohen, 1973) has not been able to verify his circumstantial conclusions, although Stanley and Lundeen (1980) did find that the frequency of tongue thrust in a bottle-fed population was "statistically greater" than that within a breast-fed population from another culture.

What is of importance in view of many of these factors, is that the nature of some of these factors is obscure. In other words, it is not clear whether some of them (open bite, digit sucking, etc.) cause tongue thrust or whether tongue thrust contributes to them. The realm of "form versus function" begins to appear. However, more of this will be discussed at a later stage.

Brauer and Holt (1965) made the observation that they were not able to determine the nature and degree of all the conjectured etiologic factors.

They based a classification system on this premise. Furthermore, they felt that the tongue's particular pattern of movements to accomplish the act of deglutition is determined by the "path of least resistance" and by hereditary factors. "Because the resistance the tongue encounters is different in most individuals, we would expect to see the many different kinds of dentofacial deformities influenced by tongue thrust patterns."

Subtelny and Subtelny (1962) noted that the clinical differentiation between a deviate muscular pattern which is adaptive and one which is causative is difficult. They stressed that an appraisal of possible etiological factors is indicated. Despite the complexity of interrelated factors "the skilled orthodontist should apply his diagnostic ability to get some clues as to whether an observed pattern of aberrant muscle function is a causative, a contributive, or an unrelated factor in any specific malocclusion".

Scott (1961) stressed the need for better, more definitive research into causal factors such as these.

A more recent statement on etiology (Proffit and Mason, 1975) listed, in general terms, three causes for tongue thrusting during speech or swallowing or both in children in the mixed dentition:

1. Adaptive behaviour, related to morphologic variations in the mouth and pharynx.
2. Neuromotor patterning that has its development in the individual's interpretation of feedback experiences.
3. The presence of a normal, if delayed, stage in the transition from infantile to adult swallowing.

These seem to lead to a more reliable etiological description, for it

seems that the possibilities are great for many etiological factors, as mentioned previously, to influence tongue thrusting, but the probable number of factors is much smaller. Which are the real etiological factors, and therefore the criteria associated with the retention of tongue thrust? If these criteria can be identified and the diagnosis can be more readily made, then therapeutic intervention can be better timed and carried out. Thus diagnosis concerns itself not only with identifying the etiological factors but also with those likely to cause perpetuation of the disorder.

3.6 Criteria Associated with the Retention of Tongue Thrust

Andersen (1963) observed that the nature of the tongue thrust "syndrome" is very complex. Information gained from his investigations suggested that it may be prudent to postpone orthodontic treatment for some of these patients, since some of them would probably show spontaneous correction of the tongue thrust "habit". He found that the only related factor in the retention of tongue thrust was thumb-sucking. Therefore, he concluded, the problem of determining which patients will show the spontaneous correction remained unanswered.

Milne and Cleall (1970) suggested that any abnormal tongue behaviour or speech disorders found in subjects after the intermediary phase of deciduous incisor loss and permanent incisor eruption, would probably also be present in the earlier complete deciduous dentition - instead of developing suddenly later, at the start of the mixed dentition.

Following a discussion of possible etiological factors and concomitant conditions, Cole and Cole (1980) suggested that there may be very few factors that could be considered reliable in terms of diagnostic signs for tongue thrust. However, they pointed out that there are factors which tend to be found more frequently among tongue thrusters than among non-tongue thrusters; even though, they pointed out, these factors have not been found to be related to tongue thrusting to a statistically significant degree. They then listed the conditions which seemed to constitute "reasonable diagnostic criteria" for determining the existence of a tongue thrust when taken in combination. That is, the first condition accompanied by any one or more of the next six conditions seemed to constitute reasonable evidence for the existence of a tongue thrust. They listed:

1. Tongue against or between the anterior or lateral dentition, and appearing to be exerting considerable force against the dentition.
2. Moderate to severe open bite.
3. Moderate to severe anterior overjet.
4. Marked circumoral activity.
5. Marked mentalis activity.
6. Moderate to severely hypertrophied tonsils.
7. General distortion of all sibilant sounds.

They then listed the conditions which seem to constitute reasonable predictors of a tongue thrust, any one or more of which is likely to persist throughout the period of mixed dentition (Hanson and Cohen, 1973):

1. Mouth breathing.
2. Sucking habits.
3. Hypertrophied tonsils.
4. A high and/or narrow anterior maxillary arch.
5. Marked circumoral activity during swallowing.
6. Any degree of open bite in the deciduous dentition.
7. Dentalisation distortion of linguoalveolar consonants, particularly sibilants.

These conditions, they suggest, tend to complicate the transition from tongue thrusting to the mature swallow; "Logically, a given patient presenting with more than one of these factors probably stands an increased chance of retaining TTS (tongue thrust swallow)."

Tulley (1969) distilled the various factors into two groups; (a) those of the endogenous tongue thrust, and (b) those of the adaptive tongue thrust. The signs of the endogenous tongue thrust were a familial pattern, and marked distortion of sibilant sounds. If there was a "poor facial pattern" and a

forward tongue posture at rest, he said, it will not respond to any kind of therapy. Bell, Proffit, and White (1980), however, indicate that correction through surgery is effective for these cases. Of the adaptive factors, incompetent lips and consequent forward tongue posture, according to Tulley, are of significance. He contends that a change in the dental form is effective in eliminating the tongue thrust. This involves orthodontically placing the labial segments in good relationship so that the upper lip can come to seal on the labial surface of the upper incisor teeth.

Hanson and Cohen (1973) found six behavioural factors and six structural factors to be associated with the persistence of a thrusting pattern in the children they studied. These were:

(1) Behavioural - greater contraction of masseter and circumoral muscles during swallows; more dentalised linguoalveolar consonants; fewer allergies; more digit sucking; and more mouth breathing; and,

(2) Structural - larger tonsils; higher and narrower palates; less buccal crossbite; greater maxillary arch circumference; and less available antero-posterior space at the level of point A.

Hanson (1976) reported that these factors above were found to be significantly related to the retention of tongue thrust. The level of significance on these factors varied from $p < 0.01$ to $p < 0.05$.

Proffit and Mason (1975) made reference to three causal factors that represent the criteria associated with the retention of tongue thrust: (1) Adaptive behaviour, related to morphologic variations in the mouth and pharynx - the probability that the tongue adapts to tooth position as well as to pharyngeal and airway dimensions; (2) Neuromotor patterning that has its development in the individual's interpretation of feedback experiences; and (3)

Delay in the transition from infantile to adult swallowing.

Pierce (1978), just as Rix (1948) had done previously, placed much emphasis on forward resting posture of the tongue due to organic or functional mouth breathing, particularly before infantile swallowing starts to mature. The aspect of habitual mouth breathing was also included. She pointed out that although the cause of some previous mouth breathing in an individual has been eliminated, the person may still breathe through the mouth habitually.

Barrett and Hanson (1978) list eight developmental changes in anatomy and physiology that foster corresponding modifications in the resting posture and movements of the tongue. These changes, they point out, are necessarily accompanied by, if not guided by, perceptual cues that are also changing. If the environment in which the tongue functions fails to develop normally along any dimension, or if the space available in the oral cavity is restricted in any other way, the thrusting pattern during infancy may persist, even throughout adulthood. These factors, they say, may deter development of normal swallowing patterns:

1. Large tongue with effects on the dentition and lingual resting postures.
2. Swallow pattern not changed due to delay in introduction of solid foods.
3. Postponement of voluntary muscle contractions of the tongue and cheeks due to extension of suckling phase.
4. Retarded growth of the mandible and/or maxilla.
5. Insufficient or delayed eruption of the incisors or molars, limiting the enlargement of the oral cavity in a vertical direction.
6. Nasal airway size is restricted by obstructions such as enlarged tonsils or swollen membranes.

7. Abnormal, genetically determined, size relationships among the mandible, maxilla, and tongue - the tongue resting in the mandibular arch rather than the smaller maxillary arch.

8. Oral perceptual skills are inadequate, leading to a lack of normal refinement of movement required for the development of the non-thrusting swallow.

These deterrents to the development of normal swallow patterns are confined to the early childhood years, and many of these speculative findings, according to Barrett and Hanson, are supported by research findings. However, none of them has been definitely proved to be true. They point out though, that evidence is substantial that alternations in normal physiological development are strongly associated with the retention of the infantile swallowing pattern.

Overall, these authors stress that anything that fosters a low forward resting position of the tongue can contribute to the retention or the development of a tongue thrust pattern. They place major emphasis on mouth breathing and its associated causal factors; lingual crossbite, encouraging the tongue to rest low in the mouth; a high or narrow palate; and vertical crowding of the tongue, as with deep overbite cases. The significance of thumb sucking however, is difficult to assess.

In the longitudinal study reported by Hanson and Andrianopoulos (1982), subjects were assessed from the average age of four years nine months to the age of eighteen years. Two associated etiological factors were studied both pertaining to the upper respiratory tract: nose/mouth breathing and surgery for removal of tonsils and adenoids. For nose and mouth breathing they found that there were more tongue-thrusters breathing through their

mouths (38.5%) than non-thrusters (27.5%) at age eighteen years. However, the reliability of this information is questionable since the information was obtained by direct questioning. For tonsil and adenoid removal it was found that comparisons could not be made because of the discrepancy in group sizes between those who had had the surgery and those who had not.

Regarding developmental patterns in individuals the findings were interesting since these were the first figures published. Prior to this study developmental patterns had been deduced from cross-sectional studies on a group basis. Usually incidence figures refer to group data. They point out that one cannot assume that an increase or decrease of incidence of a given behaviour in a group reflects that same directional change in each subject in the group. The progress of the 61 remaining individuals (seen in this study at the age of eighteen years) over the $13\frac{1}{2}$ year period covered by the research is illustrated in Fig. (109). Patterns of swallowing in individual subjects between the ages of eight and eighteen years are not nearly so stable nor predictable as are incidence figures obtained from the groups which those subjects comprise. The authors point out that an orthodontist who sees an eight-year-old patient with a malocclusion and a tongue thrust has little information on which to base any judgement concerning the prognosis for retention or remission of tongue thrust. Even if the patient has no tongue thrust at eight years, he may develop one at some time during the next ten years. Thus, the unpredictability of tongue-thrusting is demonstrated, for it seems that there are certain diagnostic criteria associated with the retention of tongue thrust. However, it is not clear what will cause a remission from the age of about eight years onward.

An observation by Gellin (1978) on the clinician's dilemma is noteworthy. Does the orthodontist treat the tongue-thruster between the ages of

INCIDENCE OF TONGUE THRUST AT AGES 4-9, 8-2, 18 YEARS
(USING CONSERVATIVE DEFINITIONS OF TONGUE THRUST ONLY)

SUBJECTS WITH TONGUE THRUST AT:	NUMBER OF SUBJECTS	
	TONGUE THRUST AT 18 YEARS	NO TONGUE THRUST AT 18 YEARS
4-9	12	18
8-2	10	8
4-9 AND 8-2	4	2
NO TONGUE THRUST AT:		
4-9	13	19
8-2	15	29
4-9 AND 8-2	7	13

(CATEGORIES ARE NOT MUTUALLY EXCLUSIVE)

Fig. 109 Table: Tongue thrust incidence (ages 4-9, 8-2, 18 years).
(Hanson and Andrianopoulos, 1982)

eight to twelve believing that possible changes to the dentition could be occurring that could be prevented, or should nothing be done on the basis that the tongue thrust is probably transient. "It is important to keep the consumer in mind when analysing these opposing views. The view of 'let's do something now' can lead to unnecessary expense. In contrast, the conservative approach of 'let's wait and observe' suggests that tongue activity is not always abnormal for the child, is not always a threat to the occlusion, and should be given an opportunity to correct itself." In the light of the longitudinal study of Hanson and Andrianopoulos (1982), the conservative view may not be such a valid one. If the findings of the study are true, and it is likely for a substantial number of normal swallowers to revert to tongue thrusting during this period, 'waiting-and-seeing' may be contra-indicated. Proffit (1977) concedes that 15% of adults do have a tongue thrust. How many of these were late developers of this pattern? By choosing the course of waiting, the probability of being right, i.e. correct in one's diagnosis, is high (85%). However, what will happen to the mistakes, the other 15% who could have benefited by earlier treatment? It might be better to consider, in detail, the other criteria for the retention of the tongue thrust pattern in order that the mistakes can be minimised.

3.7 Clinical Diagnosis

The clinical diagnosis discussion has been left until now because of its intimate relationship with the prognostic indicators of a retained tongue thrust, discussed previously. In some respects then, the following discussion represents the 'bottom line' of this chapter, drawing together the aspects which have been discussed previously.

There have been many methods of observing swallowing behaviour recorded in the literature. These methods and the interpretation of the recordings have been the major problem in coming to definite conclusions regarding deviant lingual behaviour. The list includes: electromyography, measurement of intraoral pressures, cineradiography, cinefluoroscopy, cephalometric radiography, neurophysiological methods, serial cinephotography, and others (Tulley, 1969). Videofluoroscopy and lingual electrodes have also been introduced (Cole and Cole, 1980; Yoshida, Takada, and Sakuda, 1982). Obviously, it is difficult to adopt the use of these research-oriented techniques in a clinical environment.

It has been pointed out that, essentially, tongue thrust refers to an anterior and/or lateral position of the tongue so that the tongue is visible between the teeth; this may occur when the tongue is in a resting posture, during the swallowing of any two of three media (solid, liquid, saliva), and/or speaking (Barrett and Hanson, 1978; Proffit and Mason, 1975; Proffit, 1977; Hanson, Barnard, and Case, 1969; Hanson and Cohen, 1973).

One problem that often confronts the clinician is the visibility of the tongue when swallowing. If the orthodontist cannot use sophisticated equipment then s/he, it seems, must be able to see the tongue directly. A problem arises in that many have advocated the parting of the lips when

examining the swallow (Andersen, 1963; Gellin, 1978; and others). This, according to some authors, interferes with the swallow, encouraging the tongue to protrude, giving a false impression (Proffit and Mason, 1975; Barrett and Hanson, 1978; Cole and Cole, 1980; Hanson and Andrianopoulos, 1982).

According to Rampp and Pannbacker (1979) an examination of the tongue should meet the following criteria:

1. The test must be consistent with anatomical and developmental data.
2. It should provide information that will facilitate appropriate management decisions and referrals.
3. The test should be usable with both children and adults.
4. It must be efficient and should not require a great deal of time or training.
5. It must be economical.

To these could be added that the test should be reliable and valid. These authors have devised a test based on articulation which seems to be of great benefit to speech pathologists and oral myofunctional therapists. What should the orthodontist use?

Another approach described by Cole and Cole (1980) has been to carefully paint a paste of sodium fluorescein suspended in Orabase on the tip and lateral margins of the anterior tongue, to ask the patient to swallow, and then to view the oral cavity with an ultraviolet light source in a darkened room. However, it is not possible to know whether the tongue has gone through any preliminary manoeuvres prior to initiating the swallow or not.

Cole and Cole (1980) describe the technique which has proven most useful to them. It is the one devised by Barrett and Hanson (1978) to be used

in therapy rather than as a diagnostic tool. They ask the patient to take a small amount of liquid (2-3mls) into the mouth, gather it on the dorsum of the tongue, slowly part the lips, open the mouth, and tilt the head forward. If the liquid does not escape, it is highly unlikely that the patient has a tongue thrust. However, the loss of the fluid does not automatically imply the existence of a tongue thrust. It may only mean poor neuromotor coordination of the tongue. They then part the lips for negative information. If there is no sign of a thrusting pattern, they feel comfortable in rendering such a diagnosis. If the tongue is seen to be thrusting, they feel comfortable in rendering a diagnosis of tongue thrust only after extensive additional testing and only when the apparent tongue thrust is accompanied by one or more of the conditions mentioned previously under "criteria associated with the retention of tongue thrust" (Hanson and Cohen, 1973).

Storey (1976b) has identified the need to view the tongue directly without disrupting its activity. It would appear that if vision of the tongue is obscured, the above method would be of considerable use. The author has found the following method, repeated 3 to 4 times, to be a simple and reliable way of observing tongue thrust, especially the aspect of resting lingual position:

- (1) Have the patient sit comfortably upright;
- (2) Allow the patient time to relax and to allow the oral muscles to come to rest; as Barrett and Hanson (1978) point out, some patients display "an almost continuous series of nonswallow, nonpurposive tongue protrusions" as well as continuous circumoral movements;
- (3) If there is lip incompetence, view the tongue resting posture directly, noting its position; if the lips are closed, gently move the lower lip down without causing any other muscle movement, until the tongue can be viewed, noting its position; and then

(4) Observe the action of the tongue in speech, counting from one to twenty, noting the placement of the tongue tip, especially for /s/ and /z/ sounds (discussed later). Hanson (1979a) stressed that it is more important to watch the tongue-thruster speaking than it is to listen. This is because the tongue, in these cases, tends to remain too far forward as linguo-alveolar sounds are produced, making /s/ and /z/ sound like /th/, but it does not affect the way /t, d, n, and l/ sound.

By combining the last procedure with the others a reasonably accurate assessment can be made for the initial diagnostic information. Further tests, discussed later, can be performed if there are inconsistent patterns or inconclusive observations. Although this method has yet to be scientifically scrutinised, it has been of use clinically.

Barrett and Hanson (1978) have provided the most comprehensive description of diagnostic assessment to be found, "a complete diagnostic evaluation should include a case history and a thorough examination of oral structures and their functions in swallowing and nonswallowing activities". However, most of their description which follows is concerned with swallowing activity with the description of the observation of nonswallowing activity poorly defined. This is why I have provided the previous description of observing nonswallowing behaviour.

Barrett and Hanson stress a most important point, that observations of the patient's oral behaviour "are more valid when the patient is unaware that he is being observed". Furthermore, when observing swallowing behaviour, "random, unsolicited saliva swallows are more meaningful diagnostically than swallows done on command".

They describe the use of a "rating scale" (0-1-2) for swallowing:

0 - given when the tongue does not contact any part of the anterior or lateral teeth during swallowing;

1 - given if there is linguodental contact, but only against the lingual aspect of the anterior or lateral dentition; and

2 - given if the tongue protrudes beyond the incisal edges of any of the upper and lower anterior or lateral teeth. As well, they suggest that before checking for tongue thrust during swallowing, one should check for areas of open bite, anterior and posterior, and diastemata in order to know the most likely area for tongue thrust to occur. "Thus in the case of a unilateral open bite, rather than breaking the labial seal centrally during the swallow, the examiner would break it in the area of the open bite."

Barrett and Hanson suggest that the assessment of the swallows of different media (food, liquid, saliva) be made:

Food swallows: Using a "sugar wafer" they observe firstly the general pattern of mastication and activity during bolus formation, noting that tongue-thrusters tend to have less skill in these manoeuvres, with a tendency to keep the lips open during chewing, thereby disrupting the fine coordination required to form a bolus and to move it back and forth over the occlusal surfaces of the teeth. Then by gently resting the index or third finger at the top of the larynx, and the thumb on the patient's lower lip, when the swallowing is beginning (upward movement of the larynx) the lower lip is gently but quickly depressed. One of four patterns can be then identified:

(1) If swallowing is normal, no movement of the mandible is detected. The teeth are closed, and the swallow is "executed effortlessly with the lips parted";

(2) If an anterior thrust occurs, its presence is "usually obvious", withdrawing the lower lip exposes the apex of the tongue between the incisors;

(3) In some cases an anterior thrust occurs, but breaking the labioglossal seal results in instant retraction of the tongue, possibly to prevent escape of the bolus. This retraction may be too rapid for visual detection. However, sudden closure of the teeth accompanies tongue withdrawal, and the resulting jar transmitted through the mandible is "readily felt by the fingers"; and

(4) In some cases great resistance is met when the thumb attempts to depress the lip. "These patients feel that the labioglossal seal is absolutely essential to the swallowing act." Timing is most important when breaking the lip seal. These patients usually have a "Type 2" swallowing pattern.

It is important, according to these authors, not to introduce artifacts when observing the thrust. However, sometimes difficulty will be experienced due to the speed of the tongue, or because of the covering dentition, e.g. deep overbite. The patient could then be asked to swallow with the lips parted. Most normal swallows have no difficulty swallowing this way, but the tongue-thruster will have considerable difficulty swallowing without bilabial or labiodental contact. In addition, the insertion of a tongue depressor between the upper and lower first molars on one side, just prior to the swallow, can be useful. In contrast to most normal swallows, tongue thrusters, temporarily deprived of the anterior tongue-teeth or tongue-lip seal find it difficult, if not impossible, to swallow.

Liquid swallows: They recommend that each patient be first tested drinking continuously, noting: any excessive reaching for the cup with the head and tongue; circumoral contraction; and clearing swallows as the cup is lowered.

Saliva swallows: They recommend that the patient gather some saliva and swallow on command, noting the gathering process. If there is considerable effort displayed by the facial muscles, and if there are indications of tongue thrust during gathering, this should be noted. Again, part the lips during swallowing.

Barrett and Hanson then suggest that a statement of diagnosis be made. "In addition to declaring whether or not there is a tongue thrust present, the examiner should define the type of thrust and, in some manner, assess the severity and consistency." This would apply to either swallowing or non-swallowing behaviour.

In a later paper, Hanson (1979a) updated and expanded upon these diagnostic procedures, dividing them into six "purposes" and seven "procedures":

(A) Purposes:

- (1) Determine if there is a "problem" requiring treatment;
- (2) Determine the "scope and nature of the disorder";
- (3) Provide a "basis for treatment planning and for evaluation of therapy";
- (4) "Educate" the patient and parent regarding the problem;
- (5) Determine the "motivation of the patient";
- (6) "Investigate" the possible "causes and perpetrators of the disorder".

(B) Procedures:

- (1) Observe the patient at rest and during speech, noting breathing habits, lip and tongue resting postures, and the manner in which tongue-tip sounds are produced;

- (2) Examine the oral structures, noting the occlusion, tongue size, frena, cheeks, palate, uvula, and tonsils. Note any condition restricting or limiting the space available for the tongue;
- (3) Examine oral function during biting, chewing, swallowing (food, drink, saliva), and speech;
- (4) Quantitate observations using the 0-1-2 rating scale;
- (5) Take a case history noting pertinent dental, medical, educational, or psychological treatment;
- (6) Explain findings to patient and parent; and
- (7) Motivate the patient as required.

In conclusion then, it seems that the sooner a reliable and valid way of examining tongue thrust behaviour is found (along the lines of the last three methods) and universally adopted, the sooner there will be a clearer understanding of the problem, instead of the diversity of opinion based on diversity of investigation. Following the total discussion presented thus far, with particular regard for the diagnostic identification and criteria associated with the retention of tongue thrust, which have an important prognostic bearing, we are led to considerations of orthodontic and myofunctional treatment planning. The total diagnostic picture then serves as a basis for determining which treatment is most appropriate and likely to be most effective.

