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The guidance of eruption without extraction

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The guidance of eruption by serial extraction is a well known procedure in orthodontics. The therapeutic principle consists in diminishing the bony resistance near the erupting tooth, which will then deflect in the direction of the extraction site. The problem which will be discussed in this paper is whether we might guide eruption without extraction.

It is generally suggested that, after clinical eruption, the forces of cheeks, lips and tongue play an important role in determining the ultimate labiolingual and buccolingual tooth position. However, Scott (1961) states that, the opinion that the teeth are aligned in a state of balance between the forces of cheeks, lips and tongue is a hypothesis which requires to be substantiated by experimental evidence. He states 'it should, for example, be easy to design an experiment in which cheek pressure is withheld from acting on a labially displaced canine, and observe whether in such cases the tooth remained in the displaced position'.

In my opinion, function correctors meet all requirements for an experimental device to conduct such experiments. In order to test if the position of teeth may be changed solely by eliminating cheek pressure, measurements were made from upper study models taken before and after treatment (Mosch). The casts were not selected by criteria other than narrowness in the upper jaw but all types of malocclusions were represented in this study. The sample consisted of children who were treated with function regulators alone. There was no force acting upon the premolars and molars other than the tongue. Although this work wil1 be published in detail elsewhere, provisional measuring results of 400 cases have shown that merely by withholding the cheek pressure a spontaneous widening of the dental arch could be observed with great regularity, and to an extent which coincides approximately with the norm of Pont's index. The increase of the distance between the first deciduous molars, first premolars and the first permanent molars in the maxilla is given in Table 1. The mean value of the interval between the first and second measurements reflect the dates when the models were obtained. Actually, the expansion was generally achieved much earlier. These data, as a result of careful measurements, support the conclusion that (1) tongue, cheeks and lips are in a state of balance with each other, (2) the form of the dental arch in a given case reflects the present state of this biomechanical balance. Furthermore, it is suggested that (3) the circumoral muscle band must be considered an important part of the functional matrix responsible for the morphogenesis of the dentoalveolar process.

The question arises, whether the perioral tissues may influence the tooth position during eruption. For this purpose, the eruptive path of the maxillary incisors of 114 Class II division 2 cases, who did not receive any orthodontic treatment, was observed for about two years (Falck, 1969). On average, four radiographs were taken per case. Among other results, these studies have shown that the bony layer covering the labial surface of the upper incisors became significantly thinner as the eruption advanced. Its radiopacity disappeared completely some time before clinical emergence. Meanwhile, the distance between the alveolar crest and the palatal plane decreased by 4.56 mm on average. This decreased resistance of the labial bony cover may be the main reason for the change of axial inclination observed in the initial stage of the eruption of the upper incisors; during further eruption these teeth became increasingly steeper and this is observed before clinical emergence. Our findings coincide to some extent with those of Tulley (1957). It is suggested that in Class II division 2 the tight lower lip, along with the high lip line, is a characteristic feature and may account for such retroclination.

Other longitudinal radiographic evidence should be taken into consideration. The apices of the erupting teeth change their positions in the occlusal direction. A remarkable positional change occurs in the apical base (that part of the alveolar process which houses the root apices) during eruption, particularly of the mandibular premolars and canines. The distance between their apices and the lower mandibular border often increases by 10 mm in this period. Our starting point for a biomechanical analysis of the early stage of the developing permanent dentition is the plasticity of the thin outer alveolar walls. It appears reasonable to suppose that they are easily bent outwards by the growing and erupting tooth. That may be considered the main reason for the physiological spread of teeth out of their original crowded position. On the other hand, forces of the perioral musculature have a counteracting effect and could impede this spreading. The projecting vestibular shields of function correctors (Fig. 1) intercept such restraining forces. Moreover, the traction on the apical part of the buccal wall brought about by the projecting screens (see arrow) is an additional factor which facilitates the drift of teeth in an outward direction and induces remodelling processes in the outer alveolar wall as marked by 'A'.

Occlusal films show that canines and premolars are covered buccally only by a thin bony layer. The bulges

Table 1 The increase between antimeres in the maxillary dental arch achieved by function correctors. Total number of cases: 400.

Teeth	Number of cases	Mean (mm)	S (mm)	SEM (mm)	Range (mm)	Interval between measurements (mean in months)
First deciduous molar	158	4.38	1.31	0.11	2.5 to 9	17
First premolar	125	4.71	1.53	0.14	2.5 to 9.5	21
First permanent molar	306	4.49	1.51	0.09	2.5 to 11.5	23

S = Standard Deviation.
SEM = Standard error of the mean.

produced by the erupting teeth can be palpated. Our treatment results suggest that we can guide eruption by means of projecting vestibular screens. It is clear that, under the screening effect of function correctors, the erupting teeth have drifted buccally beyond the position of the overlying deciduous molars and canines. The tooth, as an integral part of the functional matrix, is thus able to induce the formation of an adequate alveolar base. We are currently taking occlusal and occipito-frontal radiographs with a focus film distance of about 3.75 metres. Accurate head fixation provides reproducible material for longitudinal radiographic studies. Figure 2 shows initial marked crowding of the dental arches. Spontaneous relief of mandibular crowding can no longer be expected because the mandibular lateral incisors have erupted, and the lower canines and premolars display an accentuated lingual inclination which is regarded as an unfavourable prognostic sign. The roentgenograph (right), taken 2 years after the start of treatment, shows the guiding effect of the vestibular screens. The intercanine distance has increased significantly and the axial inclination of the mandibular premolars has changed markedly. Perioral pressure restraining the spread of teeth out of their original crowded position is eliminated and, instead, the outer alveolar walls come under traction, particularly in the apical area. In view of the thinness and the minor degree of calcification of the bony layer covering the erupting teeth labially and buccally, this influence of the vestibular screens meets the criteria of real orthopaedic treatment, Once the appliance is inserted, the development of the dentoalveolar process is screened from the inhibitory influence of perioral pressure, and the unfolding process is stimulated by traction on the alveolar base. A comparison between the first and fourth radiograph (Fig. 2) also shows that the apices of the mandibular canines and premolars considerably changed their position in the occlusal direction, demonstrating that the definitive formation of the apical base takes place during eruption; a fact of the utmost clinical importance, Our treatment results and radiographic examinations suggest that it is possible to guide the eruption and influence the development of the alveolar process during this critical period.

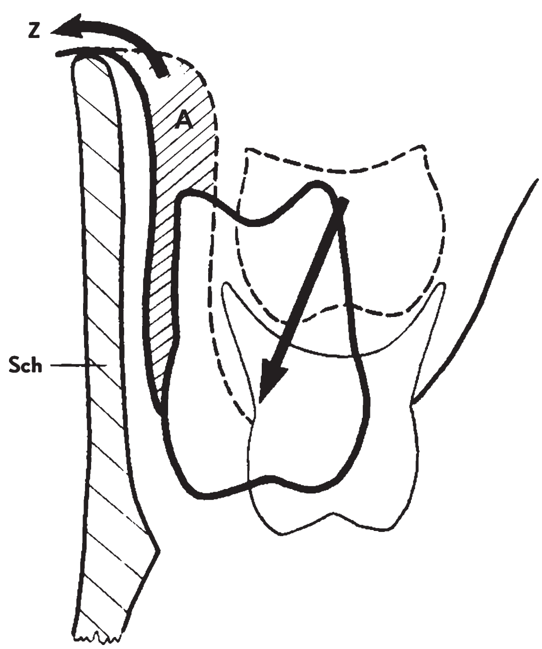


Figure 1 Schematic representation of the influence of vestibular screens upon the eruptive path and dentoalveolar development. The traction on the apical base (see arrow) facilitates the drift of erupting teeth in an outward direction and induces remodelling in the outer alveolar process, A.

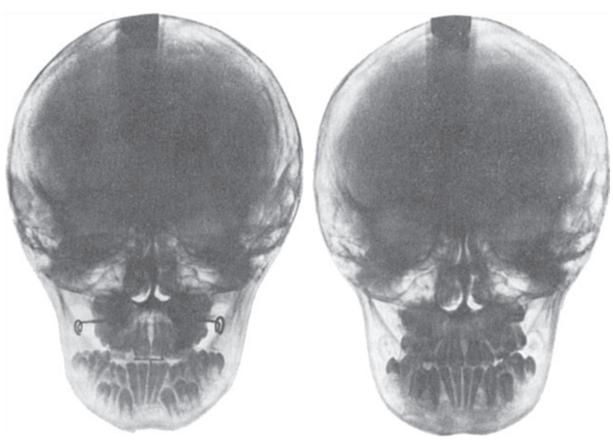
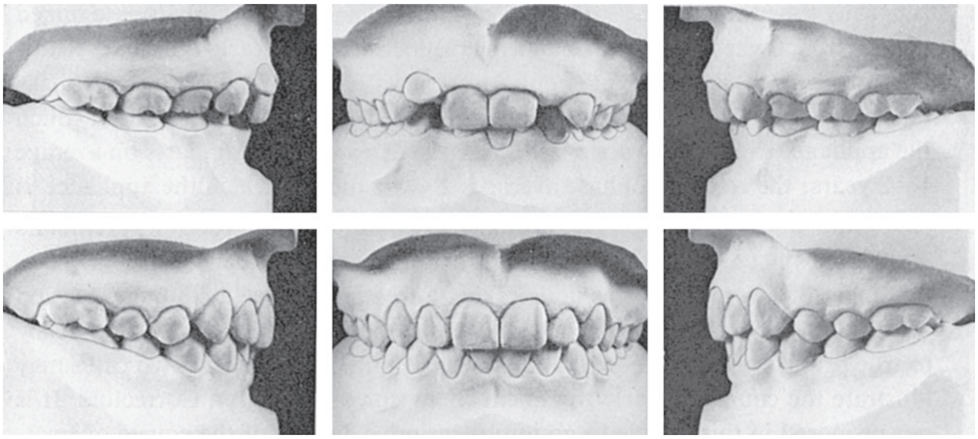
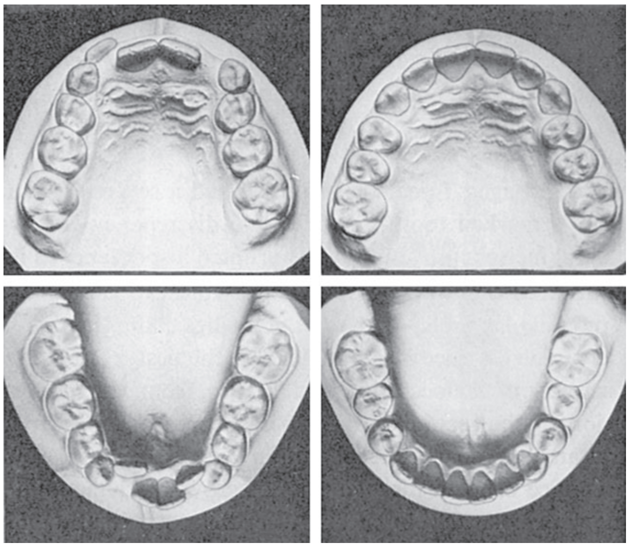


Figure 2 The first radiograph (left) of a case with severe crowding shows an accentuated lingual inclination of the mandibular canines and premolars. The fourth radiograph (right), taken two years after the start of treatment exhibits the guiding effect of function correctors.





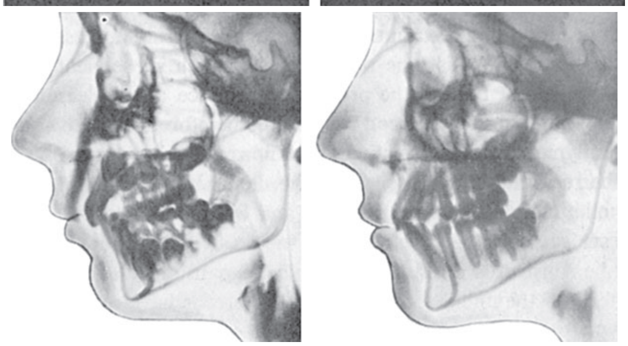


Figure 3 Case 1, Models of a girl aged 7 years 11 months at the beginning (top row) and after treatment with function correctors for 2 years 5 months (bottom row).
Figure 4 Case 1. Models, occlusal view, of Figure 3.
Figure 5 The radiographs, corresponding to the Figures 3 and 4. The apices of the erupting teeth change their positions in an occlusal direction, particularly the canines and mandibular premolars.

It should be realised that vital remodelling processes take place in alveolar bone during eruption, The importance of the remodelling process in bone growth was discussed recently by Enlow (1968), Referring to the recent research on bone growth he suggests that studies of craniofacial development should be carried out in the light of Frost's approach to biomechanical analysis. This recommendation should also be helpful for a better understanding of the remodelling of alveolar bone induced by orthodontic appliances: the reaction of the alveolar bone to orthodontic treatment is not only due to the activity of the periodontal membrane resulting in bone resorption ahead of the moving tooth and deposition behind it; because of the elasticity and plasticity of bone, the mechanical deformation of the alveolus must also be taken into consideration (Baumrind, 1969).

Investigations using autoradiographic techniques (Rohr, 1965; Tayer *et al.*, 1968; DeAngelis; 1970) and histological findings by oxytetracycline-induced fluorescence (Utley, 1968; Murphey, 1970) have revealed that mechanical stresses exert a triggering effect that provides remodelling in all parts of the alveolar bone adjacent to the moving tooth. In this way the process of relocation is induced, thereby accommodating the architectonic factor as an intrinsic feature (Enlow, 1968). The concept of piezo-electric effect in bone, as the transducing mechanism between alveolar distortion induced by mechanical activation of orthodontic appliances and remodelling processes, may be helpful for a better understanding of the cause-effect relationship in orthodontic treatment (Bassett and Becker, 1962; Bassett, 1965; Gillooly *et al.*, 1968). In the light of these investigations, the effect of vestibular screens on the development of the alveolar process during eruption may also be better understood. However, an approach to a biomechanical analysis must consider the fact that the growing and erupting tooth tends to distort the outer alveolar wall. This is a physiological phenomenon; a prerequisite for the spread of the teeth out of their original crowded positions. There is no doubt that the outward drift of the teeth may be facilitated by withholding the restricting forces of the perioral muscle band. Moreover, the traction on the alveolar base brought about by the projecting vestibular screens must be considered an important factor acting in the same manner. The magnitude of this force is considerable, provided that the appliance is correctly made, and produces tension in the soft tissues of the vestibular fold. This traction is an additional factor bending the thin bony layer covering the erupting tooth in an outward direction. The vestibular screen and the growing and erupting tooth, together, may induce significant remodelling processes in the alveolar bone. The positional change of the apical base in the occlusal direction is a reason for timing therapy with function correctors to coincide with this important developmental period. This treatment offers a unique opportunity to influence favourably the formation of the apical base. Our radiographic studies also show that these objectives may be achieved more effectively by elimination of perioral pressure and traction from outside than by pressure of a conventional plate from inside, for the alveolar walls are much thicker lingually than labially and buccally.

Measurements made from the teleradiograph of Figure 2 revealed that, during eruption, the distance between the cusps of the lower permanent canines increased by 9 mm, and those of the first premolars by 6 mm. In view of the focus-film distance of 3.75 metres, the distortion is minimal. Provided that good head fixation is used in this procedure, measurements provide exact information about the longitudinal changes occurring in the mandibular processes. Such marked widening of the mandibular dental arch can only occur if there is concomitant growth of the adjacent alveolar structures. This cannot be explained solely by bone resorption ahead of the tooth drifting buccally and bone deposition behind it, as is evident from the radiographs. In this period, the role of the growing and erupting tooth and its importance as a 'functional matrix' for alveolar growth becomes evident. In the developing deciduous dentition, as in the first developmental stage of the permanent dentition, alveolar growth is stimulated by that powerful factor. A considerable amount of work has been carried out on the increase of dentoalveolar width due to the eruption of the permanent teeth (Korkhaus and Neumann, 1931; Baume, 1943; Moorrees, 1965; Moorrees and Chadha, 1965, Moorrees *et al.*, 1969). The implication for treatment is that we should take care that the tooth is able to fulfil its task as a functional matrix. Vestibular screens meet this orthopaedic requirement by eliminating growth disturbing factors of the environmental soft tissues, and by aiding the physiological spread of the teeth. The uprighting of the mandibular premolars may be regarded as the result of diminished resistance of the environmental tissues. The tooth, which according to Atkinson (1966a,b) will follow the path of least resistance, is thus induced to change the direction of eruption. As the tooth acts as a functional matrix, the alveolar growth and development are also influenced. Guidance of eruption can thus result in a lateral and anterior increment in the alveolar process. In the critical transitional period from deciduous to permanent dentition, therefore, a careful surveillance is indicated. In our town of Zwickau, all children of school age (average 6 years), are examined by paedodontists of the school dental service. Children with severe malocclusions are transferred to our clinic and can obtain treatment if there is real parental interest. As suggested by Moorrees (1965), the therapeutic intervention should not be undertaken before the permanent lateral incisors have fully erupted, which also signals the end of the main growth spurt of arch width. In Class I and II cases, therefore, treatment is usually timed to commence in the transitional stage from the early to the late mixed dentition, i.e. when the mandibular lateral incisors are nearly erupted. At this time it is safe to assume that spontaneous relief of crowding or intermaxillary malrelationship can no longer be expected. The active treatment, during which the appliance should be worn at least half the day and all night, lasts on average 1½-2 years; the retention phase averages 2 years during which the appliance is only worn during the night. Under normal conditions of eruption, premolars and canines have erupted completely by that time. Considering that only the treatment of severe cases was undertaken, a treatment time including retention of about 3½-4 years appears acceptable. In severe Class III cases with a tendency to true prognathism treatment is commenced somewhat earlier. Two cases may illustrate the course of early treatment by means of function correctors. It is not proposed in this article to go into descriptive details

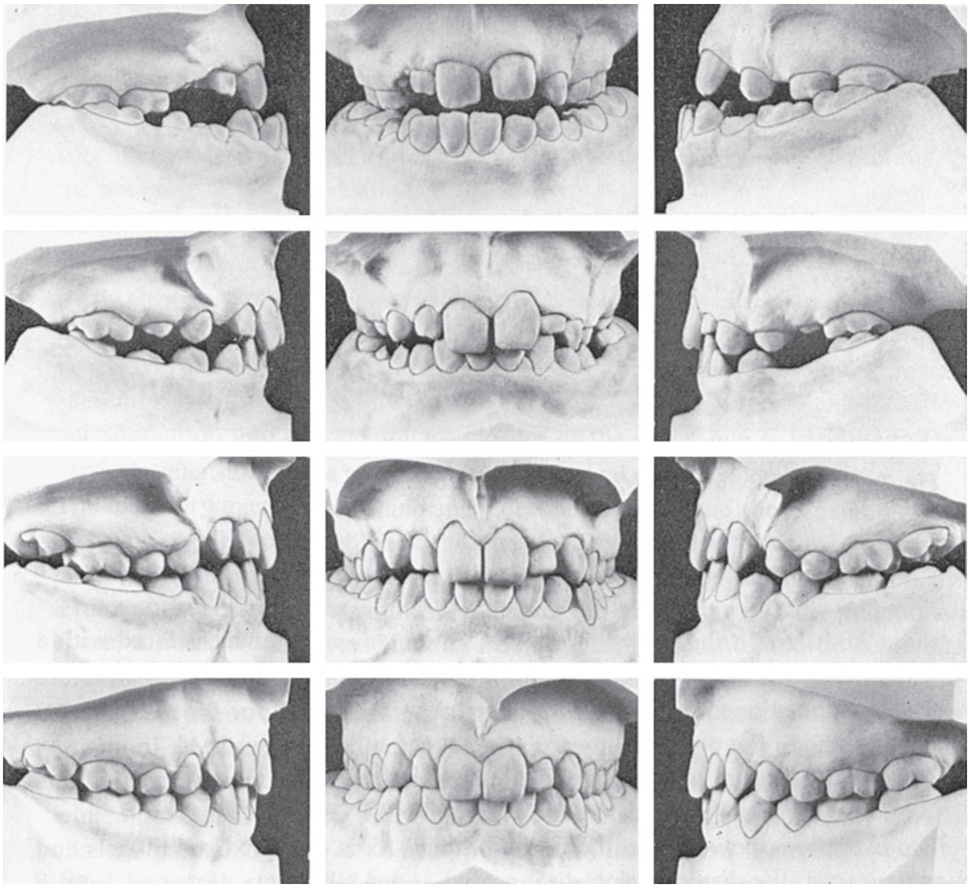


Figure 6 Case 2. First row: at the beginning of treatment; Second row: after 2 years treatment with the function corrector; Third row: after 2 years 5 months retention; Fourth row: 1 year 6 months after the retaining appliance was removed.

of the course of treatment or to give instructions in the technical and clinical manipulation of the appliances. It should only be mentioned that in the treatment of mixed dentitions specific modifications of function correctors are used.

Case 1 (see Figs. 3, 4 and 5)

This patient, a girl aged 7 years 11 months, had a severe Class II division 2 malocclusion. A marked tooth-size arch-size discrepancy is evident. Because the lower lateral incisors are almost fully erupted a spontaneous increase of the intercanine distance cannot be expected. The apical base is very small, especially in the mandibular arch. As many authorities claim, the mandibular arch, and the intercanine distance in particular, are the best reference from which to assess the severity of malocclusion and, in turn, from which to plan treatment. After eruption of the mandibular canines and premolars, extractions may be considered as an ultimate treatment solution for the inevitable crowding. However, sacrifice of teeth means a loss of growth-inducing potential needed to induce dentoalveolar development. According to Dewel (1968), the growth factor is the basic reason why serial extraction should be considered a procedure requiring caution and restraint. This is particularly true in Class II division 2 cases. Extraction in this type of malocclusion with subsequent retraction of anterior teeth that flattens the profile may produce an unpleasant concavity in the lower third of the face. We should, therefore, take advantage of the eruption dynamics for alveolar growth. The models in occlusal view (Fig. 4) show the remarkable development of the dentoalveolar arch, achieved solely by the elimination of perioral pressure and by traction exerted on the labiobuccal surface of the alveolar bone by means of the vestibular shields. This, cannot be considered a result of mechanical expansion, but rather, as a ‘screening’ effect of the appliance. The vestibular screens have removed restrictions to growth by eliminating the adverse effect of the external restraining force called ‘the buccinator mechanism’, allowing the teeth to spread and to induce growth increments in the alveolar process. The models after treatment display a considerable widening which is not restricted to the dental arch alone. There is no doubt that the apical base and the palate have also broadened. The premolars and canines are by no means tipped buccally, but, rather, are positioned in a well developed alveolar base. By expansion without concomitant broadening of the alveolar base the tooth is forced into the

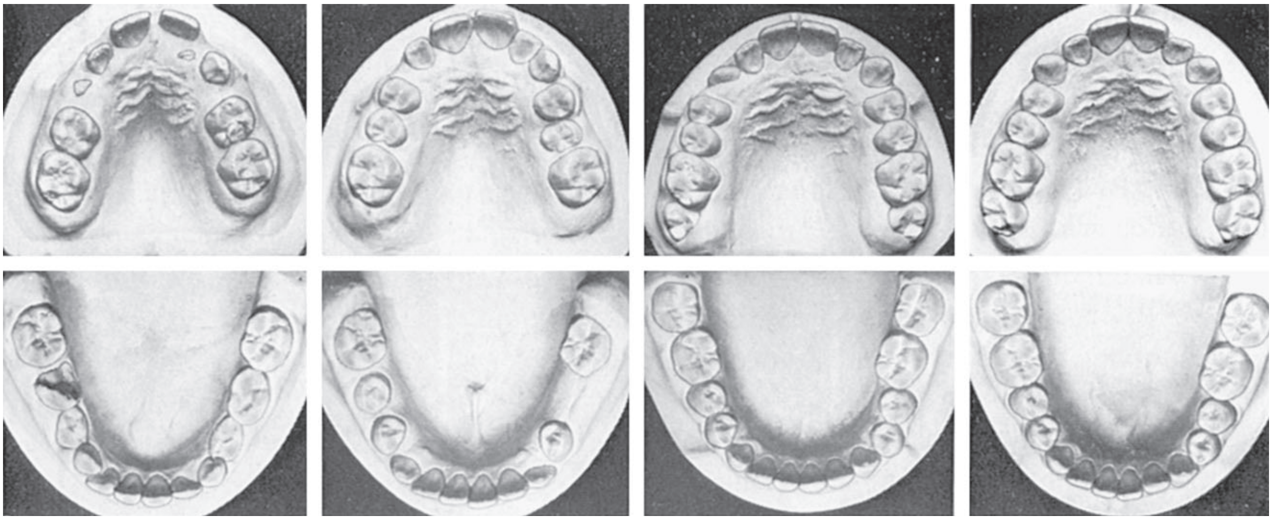


Figure 7 Models, occlusal view, corresponding to Figure 6.

circumoral muscle band. It is this external restraining force which will re-establish the previous tooth position as soon as the appliance is removed. It is not the purpose of this article to interpret the functional part of our method. It should only be mentioned that the alteration of the shape and volume of the vestibule by the appliance exposes the perioral musculature to new tactile and proprioceptive stimuli. In this sense the outer surface of the vestibular screens can be thought of as a corrected configuration of the dentoalveolar process, which is built up by acrylic to normal shape and size. In this way the perioral muscular environment is faced with a 'normalised dentoalveolar configuration' and so allowed to adapt in structure and function. Function correctors, once inserted, operate for the re-education and training of the orofacial musculature at the subconscious level. In this way 'form and function' will be corrected together from the outset. That appears to be of the utmost importance for the stability of the treatment result. The overbite is now within the normal range. As is evident from the models and radiographs, the distocclusion disappeared and ANB angle decreased from 8 to 3.5 degrees. The high lip line has been corrected and an improvement of the profile can be noted.

Case 2 (Figs. 6 and 7)

This patient, a boy aged 10 years 3 months at the beginning of treatment, showed an upper jaw extremely underdeveloped in length and width. The narrowness of the palate is particularly marked. Arch length measurements reveal a complete loss of space for one tooth in each upper buccal segment. Although the child was more than 10 years old when treatment was initiated, the real 'dental age' was about 8½ years. The unfavourable skeletal pattern and the tendency towards open bite, as evident from roentgenograms, indicate that the treatment prognosis is poor. The duration of the active treatment with the function regulator was about 20 months. Thereafter the appliance was used as a retainer and, due to the severity of the malocclusion, it was worn for a further period of 4 years 5 months during the night only.

Despite such adverse conditions a considerable development of the upper jaw has been achieved. This result was mainly accomplished by the inhibitive action of the side shields and upper lip shields of the Function Regulator III. In the first stage of treatment only a palatal arch of 0.6 mm, acted on the lingual surfaces of the upper incisors. The effect of this spring produced a slight proclination of the upper incisors. Once the reverse overbite is eliminated the palatal arch should no longer exert any pressure against the lingual surface of the incisors. The projecting upper lip shields alone should motivate the correction of the anteroposterior malrelationship.

As the models show, the initial proclination decreased markedly and, at the end of treatment, the upper incisors are steeper than at first. The models in occlusal view (Fig. 7) demonstrate that the palate and the oral cavity widened to a remarkable extent. In this way the 'functional space' increased considerably in width and now permits proper tongue posture. The low posture and protrusive activity of the tongue due to the constricted maxilla is eliminated. Functional adaptation and a concomitant closure of the open bite is permitted. The vertical dimension in the posterior part of the oral cavity increased. The maxillary mandibular plane angle decreased by 9 degrees and the gonial angle by 10 degrees. The upper face height, i.e. the distance from nasion to spinal plane, increased by 9 mm, while the lower face height, from spinal plane to menton, by 3 mm only. These findings indicate that with the enlargement of the functional space a marked improvement of the dentofacial skeleton could be achieved. The radiographs gave further interesting information about the changes occurring during treatment, retention and following observation. The angle SNA at the beginning of treatment was only 74 degrees, showing a marked lack of development of the middle part of the facial skeleton: at the end the facial angle was 78.5 degrees while the angle SNB decreased from 74 to 73.5 degrees. The angle of convexity (NAB) changed from 180 to 171 degrees. The appearance of the patient in profile is greatly different before and after treatment as regards the relationship of the upper and lower jaw bases. It is apparent however, that the depth of the middle face has markedly increased.

The overbite remained stable 2 years after removal of the retainer, and the canines are well seated in the maxillary premolar and canine embrasure. Despite the considerable broadening there is no evidence of relapse and the side teeth are positioned in good relationship to the alveolar base. As the patient is now an adult, stability of the treatment result may be hoped for. This alteration of the dentofacial structures has been brought about not least by lip closure and increase of the oral functioning space. Lip seal and the elimination of mouth breathing are important objectives of any functional therapy. For this purpose no special lip exercises need to be carried out. A slip of paper marked with 'L' should remind the child to close its lips. This 'mnemonic' is put on the school desk or writing table during homework. Holding a spatula between the lips while the child is watching television is another excellent method of achieving this objective.

A relaxed lip seal at the end of treatment is the best indication that a good accommodation of the neuromuscular system has been established.

In conclusion, it should be recognised that the alveolar process undergoes vital remodelling processes under the influence of the growing and erupting tooth. With reference to the thinness and the minor degree of calcification of the outer alveolar walls, we are able to achieve a guidance of eruption by screening perioral pressure and by aiding the unfolding process by means of vestibular shields.

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