Department of Stomatology, Medical University, Debrecen (Director: P. ADLER)

NORMAL VARIABILITY OF THE CHANGING DENTITION

P. ADLER and C. ADLER-HRADECKY

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The interest of modern orthodontics is not any more centered exclusively upon the treatment of malocclusion, but rather on controlling and directing the development of the masticatory organ. The goal is to attain the genetically possible optimum cosmetically as well as functionally in each individual child. In order to meet the requirements of the enhanced scope of this special branch of dentistry,* orthodontists and paedodontists must be familiar with every phase in the normal development of the dentition, especially with eruption and arrangement of the permanent teeth into functional occlusion. Adding well-established data to our present knowledge upon this subject is in our opinion of some value in paedodontics. The most interesting feature and the greatest difficulty in the study of the changing dentition is the extreme variability encountered in clinical as well as in population studies. It may be questioned whether or not, from the multiplicity of phaenotypes it is possible to draw any conclusion of general validity ; and if such conclusions are nevertheless drawn, how far they are valid not as regards any population group but rather for the single individuals whom the group is composed of. While *e. g.* anthropology and epidemiology are interested mainly in the behaviour of populations, the objectives of clinical medicine — and thus of paedodontics and orthodontics — concern single individuals.

The course of the changing dentition was studied by us in a selected Hungarian provincial population group, consisting of approximately 13 000 children of both sexes, between the 6th and 14th birthdays. The basis of selection was a partial (but nevertheless marked) resistance to caries in the deciduous dentition in children prior to their 9th birthday. The selection was performed, however, not on an individual, but on a community basis. Children of the total age range, born and continuously resident in communities where the prevalence of dental caries was low in the deciduous molars in examinees of 6 to 9 years, were taken into account as a whole group, without regard to caries prevalence in the individual child.

* Orthodontics is the oldest recognized speciality within the realm of dentistry.

First the mean ages were determined at shedding of the individual pairs of deciduous, and eruption of the individual pairs of permanent teeth. The normal (Gaussian) probability curve was used to show graphically the temporal course of these events. By plotting percentage values of tooth presence with advancing age in the same sex on probability paper, and similarly by plotting the probits of the tooth presence percentages, taking into account the double standard error of the tooth presence percentage values, straight lines were obtained. — Mean ages and standard deviations were read from these graphs. — Similar data were available in abundance in dental literature as regards populations other than Hungarian but none concerning the inhabitants of Hungary. Our group offers, however, some advantage in comparison to other White groups studied hitherto : with regard to the low prevalence of dental caries in the deciduous dentition, the influence of "early" extraction of deciduous teeth was minimalized upon shedding as well as eruption ages.

In agreement with data in the literature, we found considerable temporal variations within the limits of (assumed) normalcy as regards the loss of the deciduous, and the eruption of the permanent, teeth in the population. The range of temporal variability is somewhat narrower in the first phase of the changing dentition (eruption of M_1, I_1, and I_2, and shedding of the deciduous incisors), broader in the second phase (eruption of C, P_1, P_2, and M_2, and shedding of the deciduous cuspids and molars). This difference is partly due to the higher prevalence and severity of caries in the posterior deciduous teeth (molars), and to their consecutive "early" extractions, since hereby eruption is influenced not only of the successional teeth but also of some accessional ones (as *e. g.* lower M_2).

By our findings the data in the literature have been fully confirmed in that the temporal course of the changing dentition is highly variable. In this connection, some importance is to be attributed to stating whether or not the dental development of an individual child agrees with his chronological age. For the study of this problem, relying upon a suggestion of B. SIMON, tables have been constructed of the typical tooth formulae of "early" and "late" eruptors at each ½ year of age, within the ranges of assumed normalcy.

With the use of *Table I*, it is easy to state whether or not an individual child diplays some significant divergence, as regards dental development, from children of equal chronological age, used as extreme normal variants. As to the practical use of *Table I*, the following items should be taken into consideration.

(i) *Retarded teething* is diagnosed if the examine has not all permanent teeth that are shown by the typical tooth formula for a "late" eruptor of the same sex and chronological age.

(ii) *Advanced teething* is diagnosed if the examinee has more permanent teeth than are displayed by the tooth formula for the "early" eruptor of equal

Table I

Typical tooth formulae of "early" and "late" eruptor boys and girls in school age, within ranges of normalcy

Age		BOYS		GIRLS	
		"early"	"late"	"early"	"late"
years	months	eruptors		eruptors	
6	6	6edcb1 / 6edc-1	abcde / abcde	6edcb1 / 6edc21	abcde / abcde6
7	—	6edc-1 / 6edc21	abcde / abcde	6edc21 / 6edc21	abcde / abcde6
7	6	6edc21 / 6edc21	abcde6 / abcde6	6edc21 / 6edc21	abcde6 / 1bcde6
8	—	6e-c21 / 6edc21	abcde6 / 1bcde6	6edc21 / 6edc21	abcde6 / 1bcde6
8	6	6e4c21 / 6e-c21	—bcde6 / 1bcde6	6e4c21 / 6e--21	1bcde6 / 1bcde6
9	—	6e4c21 / 6--c21	1bcde6 / 1bcde6	6e4c21 / 6-4321	1bcde6 / 12cde6
9	6	6-4c21 / 6-4321	1-cde6 / 12cde6	654-21 / 6-4321	12cde6 / 12cde6
10	—	654-21 / 654321	12cde6 / 12cde6	654321 / 7654321	12cde6 / 12cde6
10	6	654321 / 7654321	12cde6 / 12cde6	654321 / 7654321	12cde6 / 12cde6
11	—	7654321 / 7654321	12cde6 / 12cde6	7654321 / 7654321	12cde6 / 12cde6
11	6	7654321 / 7654321	12cde6 / 12cde6	7654321 / 7654321	12cde6 / 12cde6
12	—	7654321 / 7654321	12cde6 / 12cde6	7654321 / 7654321	12cde6 / 123de6
12	6	7654321 / 7654321	12cde6 / 12cde6	7654321 / 7654321	12c4e6 / 1234e6
13	—	7654321 / 7654321	12c4e6 / 123-e6	7654321 / 7654321	12c4e6 / 1234e6
13	6	7654321 / 7654321	12c4e6 / 1234e6	7654321 / 7654321	123456 / 1234-67

Permanent teeth are symbolized by arabic numerals 1 to 7 (from central incisor to second molar), deciduous teeth by small letters a to e (from central incisor to second dec. molar).

age and sex. Acceleration is assumed furthermore if the examinee has a permanent tooth not present in the tooth formula for the corresponding "early" eruptor, but at the same time not all those teeth had erupted in the examinee which are displayed in the "early" eruptor's formula.

(iii) In *Table I*, deciduous teeth are also shown in the typical tooth formulae. Of practical importance are only the teeth absent from the formula of the "late" eruptors. If a tooth absent in the "late" eruptor formula is seen in the examinee's mouth, its persistence (retention) is to diagnosed. The underlying cause is then to be clarified by X-rays.

The dental age of an individual child — be it determined relying upon the typical tooth formulae, or even in a simpler way upon the number of the erupted permanent teeth — is not stated as a simple figure like chronological age, but has to be characterized by the possible maximal and minimal limits. Instead of a definite number of years and months, *a certain range of dental age* is stated. In this way due consideration can be paid to temporal variations of shedding and eruption.

It is remarkable that while temporal variability has been duly considered in the literature as regards tooth loss and eruption during the changing dentition, since beside mean ages standard deviations have often been computed, hardly any attention has been paid to variations in the sequence of eruption. Generally, sequence of eruption was confined to taking into consideration the mean eruption ages only ; sometimes a short remark is added that deviations from this sequence may occur. HELLMAN, however, apparently considered divergences in the sequence of eruption — established relying upon the mean eruption ages of the individual teeth — to be characteristic of certain orthodontic anomalies.

In our opinion, the sequence of eruption cannot sufficiently be characterized by confining ourselves to the mean eruption ages. In our material we found differences in the sequence of eruption, relying upon percentage values of tooth presence, *e. g.* between the sequences of the 10th, 50th, and 90th percentiles *(Fig. 1)*. Differences of similar type are obvious as regards the shedding sequence of deciduous teeth *(Fig. 2)*.

Even more marked are, however, the differences if the sequence of eruption is studied not in the population (as shown in *Figs. 1* and *2*), but in individual children. Studies of this kind were carried out by ADLER and GÖDÉNY, CLEMENTS et al., LO and MOYERS, more recently by GARN et al., and by ADLER.

Our studies in Hungary have shown that in most cases a certain interval occurs between the eruption of the last tooth in the first, and the first one in the second, phase of permanent tooth eruption. In the upper jaw, comparing the sequence of eruption of the lateral incisor (I_2) and the first premolar (P_1), the exceptions amount to approximately 2,5 to 3 per cent, whereas comparing I_2 with C in the lower jaw, a reversed sequence of eruption is encountered in only 1 per cent *(Fig. 3)*. In explaining the difference in the frequency of the eruption sequence's reversal, the fact is to be taken into account that aplasia of the upper I_2 is not uncommon in White populations. In the grammar-

school children of Debrecen, I. NAGY found this anomaly in approximately 1,7 per cent; this is in excellent agreement with our present findings as regards the difference of reverted eruption sequence.

In the first phase of the changing dentition, we found that from the homologous incisors the lowers erupt markedly earlier than the uppers. Earlier

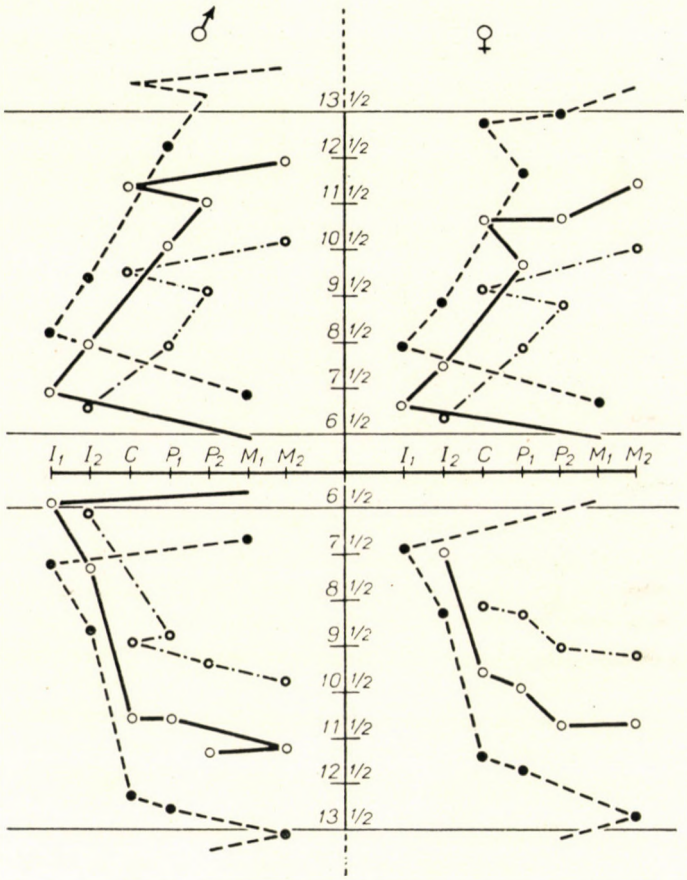

Fig. 1. Sequence of permanent tooth eruption in boys and in girls, in the upper and in the lower jaw, in reliance upon the 10th, 50th, and 90th percentiles of tooth presence.

10th percentiles: black dots connected by —·—·—·
50th percentiles: white dots connected by ————
90th percentiles: black dots connected by — — — —

eruption of an upper incisor — as compared with its lower mate — was exceptional. As regards the first molars, the lower ones erupted earlier in the majority of the subjects, but in approximately 25 per cent of our material the upper first molars were in advance of the lowers. — In the upper jaw, the usual sequence of eruption was M_1—I_1 — I_2 (encountered in approximately 98 per cent of the population). In the mandible, however, exemptions were found in

the sequence of eruption of M_1 and I_1. Mostly, M_1 erupted earlier, but a reversion of the eruption sequence was found in approximately 14 per cent of the examinees. I_2 erupted practically in no instance earlier than I_1. Thus, if in a child the lower I_2 is seen to erupt before I_1, the rather infrequent but nevertheless typical aplasia of the central incisor is to be taken into account.

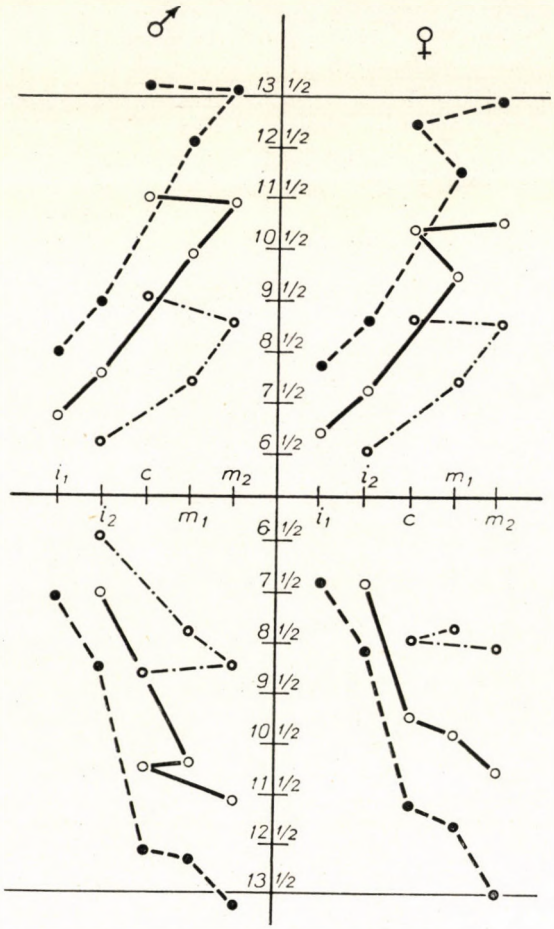

Fig. 2. Sequence of loss of the deciduous teeth in the upper and lower jaws of boys and of girls, in reliance to the 90th, 50th and 10th percentiles of deciduous tooth presence.

90th percentiles : black dots connected by ·—·—·—
50th percentiles : white dots connected by ————
10th percentiles : black dots connected by — — — —

Considerably more variability is displayed in the sequence of eruption during the second phase of changing dentition. In the upper jaw P_1 usually emerged first, and M_2 last. Earlier eruption of P_2 than of P_1 occurred in hardly 5 per cent of the examinees ; earlier emergence of C than of P_1 was even less

frequent. On the other hand, eruption of C occurred later than of M_2 in 24 per cent of boys, and 16 per cent of girls. M_2 emerged before P_2 in somewhat more than 10 per cent of the examinees. In the mandible, C and P_1 erupted markedly earlier than P_2 and M_2. In girls, in 65 per cent the first tooth to erupt was the cuspid (C), while in boys there was no marked preponderance of this tooth over P_1 (in 47 per cent of boys C erupted prior to P_1 ; in 39 per cent P_1 prior to C ; while in the remaining 14 per cent emergence of these two types occurred practically simultaneously). Eruption of P_2 before C occurred in approximately 11 per cent of male, but only in 5 per cent of female examinees. In some

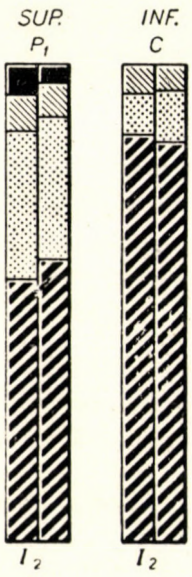

Fig. 3. Mutual eruptional stage of the upper I_2 and P_1, and of the lower I_2 and C in boys (left of the double columns) and in girls (right in the double columns).
The percentage of examinees displaying two incisors and no premolar or cuspid is *thick streated*
Percentage of examinees with two incisors and one premolar or cuspid is *pointed*
Percentage of examinees with one incisor, and no premolar or cuspid is *thin streated*
Percentage of examinees with one incisor and one premolar or cuspid, one premolar or cuspid and no incisor, two premolars or cuspids and one incisor or no incisor is noted : *black*
Number of examinees in comparing the two pairs of teeth in the upper jaw: 1967, in the lower jaw : 1880 h

instances M_2 erupted earlier than C ; this sequence was encountered in 14 per cent of the boys, and in 5 per cent of the girls. P_2 erupted usually much later than P_1 ; exceptions were encountered in less than 10 per cent. As regards the sequence of emergence of P_2 and M_2, an advance of the premolar was somewhat more frequent, but advanced eruption of M_2 was nearly as frequently met with.

Comparing the homologous upper and lower pairs, in agreement with data of the literature an advance of the lower ones was found as regards C

and M_2. Earlier eruption of an upper cuspid was seen in boys with approximately 10, in girls with less than 5 per cent frequency. With the second molars, reversal of the eruption was found in both boys and girls with approximately 10 per cent frequency. — As regards premolars, text-books emphasize the earlier eruption of the upper ones. This was true in the majority of our material but a reversed sequence was not infrequent either. Exemptions from the general rule concerning the first premolars was observed in 18 per cent of the boys and 30 per cent of the girls. Earlier eruption of the lower second premolar in comparison with the upper one was encountered with 27 and 40 per cent frequency in boys, and in girls, respectively.

Although teeth are arranged in symmetrical pairs, during the changing dentition transitory asymmetries are often seen. Bilateral mates of teeth do not erupt at the same time in many a child. Discrepancies often occur between the right and left halves of the jaws also in the sequence of eruption. According to our experience (ADLER), such asymmetries are considerably more frequent in the second than in the first phase of the changing dentition.

As it has been pointed out, divergencies from the usual sequence of eruption are rather frequent. Therefore, in our opinion, a reversal of the usual sequence of eruption cannot be regarded in most instances as pathological. Such reversals often result after the early extraction of a deciduous tooth when its successor erupts considerably earlier than it should in the normal course of events (after the natural shedding of the deciduous predecessor), prior to several other teeth whose normal eruption occurs at an earlier age but is not altered in the examinees. — Findings of this kind were most frequently recorded in connection with deciduous molars and permanent premolars. As a sequel of this we found in the examinees a premolar erupted on the one side of one jaw, although this tooth does not appear in the typical "early" eruptor tooth formula of the equal sex and chronological age, but other teeth were still absent that are contained in the typical tooth formula of the "early" eruptors. As has been pointed out when discussing the temporal variability of eruption and the dental age, these cases are regarded as instances of advanced dental development. Clinically, an importance can hardly be attributed to them.

Taking into consideration the variations in the eruption age and the sequence of eruption, a correct diagnosis of the anomalies of replacing the deciduous teeth can hardly be expected from a single examination of school-age children. Anomalies of the changing dentition may be suspected in all cases of retarded shedding or eruption, especially if there has emerged a tooth that usually erupts later, while teeth usually erupting at an earlier age are not yet present in the mouth, first of all if a tooth of the second dentitional period emerged before all teeth of the first period had erupted. Unfortunately, we are not able to recognize at due time those disturbances of the changing dentition — relying upon either normal variations of eruption ages, or on the

typical tooth formulae, or upon any other criterion — which would need early treatment or at least permanent control, as *e. g.* aplasia of the upper lateral incisor, or of the lower or upper second premolar on the one hand, aberrant eruption and imminent retention of the permanent cuspid or a permanent premolar, on the other hand. When disturbances of this kind are recognized, it is mostly necessary to start treatment by appliances in order to correct the malocclusion or the sequelae of aberrant development.

Considering the great variability of eruption ages and of the sequence of eruption, it seems questionable whether or not there is any reliable criterion during the period of changing dentition which would permit to recognize aberrations from the normal. We have been able to show that such a criterion actually exists, namely the duration of the "edentulous interval", *i. e.* the time elapsing between the natural shedding of a deciduous tooth and the emergence of its permanent successor. It was pointed out earlier (ADLER) that a disturbance of the dentition change has to be suspected if the emergence of a permanent tooth does not occur within two months after the (natural) shedding of the deciduous predecessor. It is noteworthy that the duration of the "edentulous interval" is rather constant in "early", "average", and "late" eruptors.

Summary

Variability of the mean ages at eruption of the individual teeth and of the sequence of tooth eruption have been dealt with, with regard to population and clinical studies. While there are reliable methods for population studies, none has been known to permit an early diagnosis of disturbances of the tooth elimination and replacement process in surveying school-age children. The main reason of this lack of proper methods is the great individual variability in the course of changing dentition. Of all characteristics of this peculiar developmental period, the duration of the "edentulous interval" has proved to be subject to the least variability.

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НОРМАЛЬНЫЕ ВАРИАЦИИ СМЕНЫ ЗУБОВ

П. АДЛЕР и Ц. АДЛЕР–ХРАДЕЦКИ

Авторы излагают изменчивость времени выпадения молочных зубов, и прорезывания постоянных зубов, далее порядка прорезывания зубов, с одной стороны, с точки зрения популяции, а с другой, в отношении клиники. Для исследования смены зубов среди популяции имеются подходящие методы, однако, нет возможности в ходе массовых исследований для раннего распознавания у детей расстройств в смене зубов. Одной из главных причин этого является большая индивидуальная изменчивость процесса смены зубов. Среди характерных данных смены зубов оказалась самой постоянной величиной продолжительность интервала отсутствия зубов.

DIE NORMALE VARIABILITÄT DES ZAHNWECHSELS

P. ADLER und C. ADLER-HRADECKY

Die Variabilität der mittleren Ausfallszeiten der einzelnen Milch- und der mittleren Durchbruchszeiten der einzelnen bleibenden Zähne sowie der Durchbruchsfolge der Zähne wurde in bezug auf Populations- und klinische Studien diskutiert. Während für Populationsstudien geeignete Methoden zur Verfügung stehen, ergibt sich keine Möglichkeit der Frühdiagnose der Zahnwechsel-Störungen in Rahmen von Reihenuntersuchungen. Die Hauptursache liegt in der hochgradigen individuellen Variabilität im Verlaufe des Zahnwechsels. Von allen diese Entwicklungsphase betreffenden Zahlenangaben erwies sich die Dauer des »zahnlosen Intervalles« als den geringsten Variationen unterworfen.

Prof. Dr. Peter Adler
Dr. C. Adler-Hradecky
} **Debrecen, 12. Fogászati klinika, Hungary.**