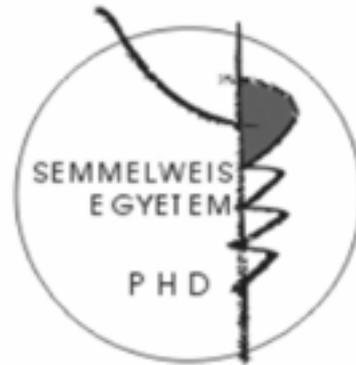


# **Examination of orofacial orthopaedic disorders associated with spinal deformities**

PhD Theses

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## INTRODUCTION

The literature exploring the relationship between the spinal deformities responsible for the development of the postural disorders and the different dentofacial deviations goes back a long way. The majority of these publications deal with the dentofacial relevance of the scoliosis, some of them are on the orofacial orthopaedic deformities associated with the hyperkyphosis.

This publication provides the results of an overall research series that determines the dentofacial feature characteristic not only to the scoliotic deviations but also to the other most frequent spinal deformity – M. Scheuermann – and even to the postural deformities of different directions showing no spinal deformities yet.

The first part of the publication presents the orthopaedic features characteristic to the examination groups as well as the examination methods thereof. The former research results are provided in details; they present a description of the dentofacial features going together with the orthopaedic deviations.

The correlations between the individual orthopaedic parameters and the dentofacial deviations presented in the former publications are mainly justified, but many new correlations are determined, too. The majority of these are based on the examination methods that have not been used in the case of such a patient group so far. A group of the new examination methods used in the early phase of the research has not been used later due to the poor scientific value of their outcome. The other group of the new examination methods provided outcomes that significantly contributed to the development of the dentofacial character of the examined patient groups. The ponderous use of the mentioned methods in the digital image diagnostics made necessary their modernisation. It led to the development of the software analysing radiograms that is capable of making an overall mandibula asymmetry examination due to its easy handling and very broad data analysing capacity.

The last part of the publication provides a detailed description of the outcomes of the former scientific researches serving as the basis of the mentioned examination software as well as the practical steps of the operation thereof.

The aim of the presentation of the examination results published and of the asymmetry examination software (that is intended to be a useful tool also for the interdisciplinary early recognition) is to provide a wider – and mutually useful – knowledge for the specialists of the two fields, orthopaedics and orthodontics in order to prevent and totally cure the orthopaedic and dentofacial deviations developing at the same age.

## OBJECTIVES

In the first stage of my research I performed the jaw-orthopaedic screening assays of patient groups having the two most common spinal deformities. The examinations – besides the routine orthodontic diagnostic methods – were completed by epidemiologic and special instrumental examination methods recommended by the WHO in order to get the most possible overall picture on the craniofacial features of the mentioned groups after analysing and processing the data. I expected the justification of the correlations in the literature from the analysis of the results and the comparison to the orthopaedic features; at the same time the goal was to explore new correlations by applying more comprehensive examination methods.

In the second stage of my research I examined a patient group with scoliosis in order to determine the frequency of the dentofacial asymmetries found among children with scoliosis. In the course of the analysis of the used frontal cephalograms the aim was to screen the skeletal asymmetry indices showing the closest correlation with spinal deformities.

In the third stage I performed the routine orthodontic screening assay on a patient group consisting of children with scoliosis and Scheuermann's disease, completed with lateral cephalogram and OPG analyses. The results were compared to the results of a routine orthodontic screening assay of an examination group being healthy in terms of orthopaedics, performed under the same conditions. The aim was – besides screening the orofacial orthopaedic variables characteristic to the patient group – to examine variables that are characteristic to the individual spinal deformity groups in terms of their frequency and/or size.

Besides the examination of the possible chains of cause and effect the next task was to explore the associated malformations being present at patients with early malformations in the two fields. The number of the widespread examination methods had to be reduced. In order to reach it, the aim was to reduce the time of the simplified orthodontic measurements (they have a very high value for the examined patient group) as well as the simplification thereof that was essential from the point of view of the personnel of the paediatric and orthopaedic surgery hours. The performance of the asymmetry measurements on the OPG and on the facial photos – both carrying the most important dentoskeletal parameters – requires a lot of time and expertise. I intended to help the performance of these measurements done by inexperienced staff through self-developed software whose application makes more simple and quicker not only the performance of the overall interdisciplinary screening activity but also the analysis of the dentoskeletal asymmetry conditions on the OPG (that is a basic radiogram in the field of orthodontics) could become a routine activity.

Finally, by using the prepared software on a patient group having had rasterstereographic and orthodontic examination I performed a comparative evaluation between the mandibular asymmetry values as well as lateral cephalogram variables and back contour morphology indices (these features formerly showed the closest correlation) in order to justify and confirm our former results as well as to explore new correlations. In the course of the asymmetry measurements of a big examination group the goal was – besides testing the analysing software – to filter those asymmetry indices that could have disease-marker importance in the early discovery of the spinal diseases as a part of a possible orthodontic screening protocol.

## METHODS

### Examination groups

Based on the objectives, the examinations were performed using different examination methods and on different examination groups in several stages.

#### *Examination group I:*

Forty children diagnosed with different spinal deformities at the Department of Orthopaedics, Heim Pál Children's Hospital were selected to the group, along the selection criteria ( - freshly diagnosed spinal deformities; - negative orthodontic anamnesis). Average age of the group: 15 years 6 months; min.: 9 years 9 months; max.: 18 years 9 months; SD: 2 years 7 months.

#### *Examination group II:*

Two groups were involved in the examination series. The patient group consisted of the children freshly diagnosed with scoliosis at the Department of Orthopaedics, Heim Pál Children's Hospital. Average age of the group: 16 years 6 months; min.: 8 years 11 months; max.: 19 years 8 months; SD: 1 year 1 month. The group involved 22 moderate (Cobb value < 25°) and 14 severe (Cobb value  $\geq$  25°) cases of scoliosis. The control group consisted of the children sent to and continuously registered at the Department of Orofacial-orthopaedics and Orthodontics, Heim Pál Children's Hospital who complied with the selection criteria ( - negative orthopaedic anamnesis; - freshly diagnosed orthodontic problems). Average age of the group of 44 people: 11 years 4 months; min.: 10 years 2 months; max.: 17 years 8 months; SD: 0 year 4 months.

#### *Examination group III:*

Out of the two groups of the third examination series patient group consisted of 51 children freshly diagnosed with Scheuermann's disease and scoliosis at the Department of

Orthopaedics, Heim Pál Children's Hospital. Average age of the subgroup of 23 children suffering from Scheuermann's disease: 14 years 8 months; min.: 10 years 8 months; max.: 17 years 5 months; SD: 1 year 8 months. In the group 15 children had severe and 8 children had moderate spinal deformities. Average age of the subgroup of 28 children suffering from scoliosis: 13 years 5 months; min.: 8 years 5 months; max.: 17 years 3 months; SD: 2 years 3 months. 19 children had severe scoliotic deviations and 9 children had moderate scoliotic curvatures.

The control group of the examination series was created of children registered at two pedodontic screening assays (one in Budapest and one in the countryside), under the same examination conditions and methods, based on the determined selection criteria (- negative orthopaedic anamnesis; - negative orthodontic anamnesis). Average age of the group: 13 years 8 months; min.: 11 years 7 months; max.: 17 years 0 month; SD: 1 year 5 months.

*Examination group IV:*

The members of the last examination group were selected from 320 children registered at the orthodontical consultation in Germany. 271 children complied with the selection criteria (- negative orthopaedic anamnesis; - negative orthodontic anamnesis; - rasterstereographic back contour analysis, OPG and lateral cephalogram made during the examination). Average age of the group: 11 years 8 months; min.: 7 years 2 months; max.: 16 years 12 months; SD: 2 years 0 month.

**Examination methods**

Due to the volume limitations I provide only brief description instead of presenting the entire examination series in details. One part of the examination methods I used during my research was the standard orthodontic examination method, the other part was directed by the provisions of the oral health check protocol elaborated by the World Health Organisation – to the unified epidemiologic surveys – and these were completed by the methodological principles recommended by Mühlemann for the examination of dentofacial anomalies.

The examination also contained methods whose applications have been unprecedented earlier in the domestic researches according to the literature. These cover the asymmetry measurements on the scanned form of the plaster samples as well as on the OPG. The digitalised version of this latter was developed into computer software as an innovative product of the research.

## RESULTS

The comparative analyses applied at the individual examination groups partly justified the former statements of the literature, and on the other hand they resulted in many correlations that could help – as a basis of further researches – exploring the correlations of the two examined regions more detailed.

### *Evaluation of the examinations of Group I*

The descriptive statistics of the orthopaedic parameters provided no unusual data.

In the course of the evaluation of the dentofacial parameters the direction of the facial scoliosis determined by the extraoral examination showed surprisingly few zero values; it is equivalent with the symmetric face. It is considerable that almost half of the cases showed – besides the right-guided convex facial scoliotic curvature – left-guided scoliotic main curvature of the spine that is present at 59.1% of the examination group. As regards the direction, the mentum deviation measured during the skeletal examinations did not show significant difference – though it was present at 57.5% of the cases. A similar result emerged at the examination of the inclination of the mandibular plane, too; it was present to a higher extent (82.5%), without significant differences regarding the directions. The examination of the mandibular position showed significant difference between the two sides; the left positioned lower jaw was twice more frequent, and this supports the direction examinations of the facial scoliosis at skeletal level. The examination of the dental midline shifts performed on the frontal cephalograms showed significant dominance of the right-directed shifts at both jaw levels. In the course of the examination of the plaster samples, the bilateral crossbites proved to be much more frequent than the unilateral deviations. According to the Angle classification used for analysing malocclusions, the position of the first molars is symmetric at the 75% of the examined group. According to the symmetry examination of the individual dental arches, the upper left first and lower right first molars have a more mesial position. The mentioned antero-posterior asymmetry is bigger in the case of the upper dental arch. The noises found in the course of the functional examinations of the temporomandibular joint had the same presence in both sides; the common presence was significantly more frequent compared to the unilateral presence. The left-guided mentum deviation registered during mouth opening was significantly more frequent; this result functionally supports the direction examination of the mandibular position and the facial scoliosis.

The comparative examinations of the orthopaedic and dentofacial parameters confirmed the more frequent presence of the right convex facial scoliosis in the case of the left main curvature direction; as well as the left convex scoliosis found more frequently together with the

right main curvature direction – the correlation, however, cannot be regarded as statistically close. The degree of the mentum deviation, however, shows correlation with the degree of the right convex scoliotic spinal curvature. In orthopaedic comparison, the postural symmetry values showed opposite correlation with the side of the scoliotic spinal curvature. In the case of the variables measured on the plaster samples we found correlation between the presence of left side crossbite and the degree of the scoliotic main curvature. The presence of the asymmetric first molar relation also showed close correlation with this orthopaedic parameter. The degree of dental midline shifts is also in close correlation with the absolute value of the main curvature. The direction of the functional mentum deviation perceived during the mouth opening was more frequently associated with the scoliotic main curvature of larger degree; it was opposite of the direction of the two variables since they were not in close correlation with each other.

#### *Evaluation of the examinations of Group II*

Opposite of the first examination group, the majority of the second group had right convex scoliotic main curvature.

The first examination step was to analyse the maxillary depth on the frontal cephalograms. The inclination of the maxillary plane was missing less than 20% in the cases of both the patient and the control group. In the case of the control group the proportion of the inclined maxillary planes towards any sides, opposite of the scoliotic group where the cases with left inclination were twice more frequent. In the course of the examination of the inclination of the mandibular plane, in the control group the lack of the inclination was twice more frequent compared to the scoliotic group, while the proportion of the inclinations towards any sides were similar in the case of both examined groups. At the examination of the inclination of the occlusal plane there were only very few children with no inclination in the scoliotic group (2.78%); in the control group these were missing. If we examine the direction of the inclination within the groups, the double frequency in the case of the right-inclined occlusal plane is considerable in the case of the scoliotic group, while at the control group the presence of left-inclined occlusal plane is almost eight times more frequent. If we examine the inclination of the base of the jaws and the inclination of the occlusal plane, the independent inclination frequency of the latter is visible. In the course of the postural symmetry examinations the left-positioned mandible was dominating but the control group was characterised by significantly bigger deviation proportions. The further examination determined the deviations of any anatomic formations from the skeletal midline by measuring the length. The deviation of the spina nasalis anterior occurred much more in the scoliotic group than in the control group. In the case of both groups right-side deviations were more frequent, but the

values of the scoliotic group were much higher compared to either the opposite side deviations or to the control group. The shift of the upper dental midline was missing to a similar proportion in both examined groups. Scoliotic group was characterised by right-shifted upper midline, while left-side shift characterised the control group. In the case of the lower dental midline both groups were characterised by right-guided deviation, with smaller differences. The examination of the mentum deviation resulted in similarly mixed outcomes. At both examination groups almost half of the cases showed the mentum deviation toward the more frequent direction. So, mentum had mainly a right-guided deviation, while control group had a left-guided deviation.

In the case of the individual groups – besides the frequency values determined for the different dentofacial parameters – the differences between the measured values also deserve attention. The examination of all the four angular deviations showed significant difference between the average values of the two groups. In the case of the maxillary plane not, but the average values of the inclination of both the mandibular and the occlusal planes were significantly higher as they were in the control group. Similarly, the difference between the postural symmetry average values was also significant; the different signs show different side average positions for the two groups regarding the mandible. In the course of the examination of the average values of the deviation linear measurements, the values of the two groups showed significant difference for all the four measurements.

In the course of the comparative examination of the groups generated on the basis of the severity of the orthopaedic deviation, only the case of maxillary inclination showed significant difference between the values of the subgroups. In the course of the comparisons significant difference emerged between the individual subgroups and the adequate values of the control group.

#### *Evaluation of the examinations of Group III*

The third examination group contains 23 children with sagittal pathological spinal curvature (M. Scheuermann) and 28 children with frontal pathological spinal curvature (scoliosis idiopathica); they were divided into subgroups: moderate and severe ones.

The Angle classification resulted in the dominance of cl.I. for all examined groups. The bilateral cl.II. difference had the most frequent occurrence among children with Scheuermann's disease. The determination of the overjet showed considerably higher average value in the case of the groups with spinal deformities. These values were changing in line with the severity of the deformities in both cases. The extreme overjet was significantly more frequent in the case of the children with Scheuermann's disease, and it was changing in line with the severity of the orthopaedic deformities. Also the group with Scheuermann's disease was characterised by

higher overbite average values, changing in line with the severity of spinal deformities within this. This is followed by the values of the scoliotic group where smaller average values are associated with more severe spinal deformities. The overbite values over 5 mm – qualified as a deep bite – were twice more frequent at children with Scheuermann's disease compared to their fellows with scoliosis. The frontal open bite cases (relatively small in number) were more frequent in the scoliotic group. The examination of the lateral crossbites showed equal proportion of uni- and bilateral differences at children with Scheuermann's disease. Though at the scoliotic group the unilateral difference was three times more frequent. The degree of the dental midline deviations of the frontal region was the highest in the scoliotic group, while the values of the Scheuermann and the control groups were almost the same. In the case of the Scheuermann group the degree of the midline shift decreased in line with the severity of the orthopaedic deformities; it was opposite of the scoliotic group whose values increased in line with the size of the scoliotic main curvature. The examination of the frequency of the midline shifts resulted in an increasing order of scoliosis:control:Scheuermann. The crowdings and spacings of the frontal region are more frequent in line with the severity of the orthopaedic deformities. The noises registered at the level of the temporomandibular joint were the most frequent at the group of children with scoliosis, then in the control group and finally in the Scheuermann group. The frequency of the mentum deviation observed at mouth opening followed the increasing order of scoliosis:Scheuermann:control. The registration of the differences between the two sides showed the dominance of the left side deviations. In the course of the examination of the lateral mandibular deviation I measured symmetric values most frequently in the Scheuermann group, then in the scoliotic group and finally in the control group. The facial asymmetry registered on the frontal facial photos was three times more frequent in the case of the Scheuermann group, twice in the case of the scoliotic group, compared to the control group. At both patient groups facial symmetry was more frequently associated with more severe spinal deformities. The evaluation of the lateral cephalograms showed difference in the case of the vertical measurements compared to the average values characteristic of the average population. The values of both patient groups were lower in all cases: at the facial axis, facial height and mandibular base plane. Except for the values of the lower facial height and the mandibular base plane the average values of the scoliotic group were higher than the average values of the Scheuermann group. As regards the examined orthopaedic patients, scoliotic children were characterised by a slightly forward positioned maxilla, a less backward positioned mandible, a less down positioned and/or a backward positioned mentum, a less lower facial height and a smaller mandibular base plane, compared to those suffering from Scheuermann's disease. The asymmetry examinations of the OPGs

emphasise the longer size of the ramus of the mandible in the case of both groups, measuring significantly higher values at patients with Scheuermann's disease. On this section the asymmetry indices were also higher at the mentioned group. In the course of the examination of the subgroups more severe orthopaedic deformities were associated with higher asymmetry indices.

#### *Evaluation of the examinations of Group IV*

The orthopaedic parameters of the fourth examination group were provided by the rasterstereographic analysis. It means that the back contour morphology was mapped through a simultaneous registration of the deviation of different planes, without taking into account the threshold limit values separating the healthy and unhealthy categories.

With the help of the statistical methods, out of the 12 measurements we selected 3 determining the sagittal and 3 determining the frontal curvatures and the positional deviations of the spine in the most precise way. For the comparative examinations eleven variables measured on lateral cephalograms as well as 36 asymmetry variables measured on OPGs were used.

Flèche cervicale is in close but opposite correlation with the maxillary depth as well as the aesthetical line according to Ricketts determined at the level of soft tissues. Out of the asymmetry variables determined on the mandible, the entire ramus length as well as the steepness of the inclination of the mandibular corpus show close correlation with the orthopaedic parameter flèche cervicale. The hyperkyphotic back together with the forward tilted head posture is associated with the backward positioned maxilla, retracted lips, the increased ramus length and the mandibular base plane.

The flèche lombaire shows a moderately close correlation with the average of the ramus length. The accentuation of the lumbar lordosis is associated with an increased ramus length.

The trunk inclination shows opposite correlation with the interincisal and conical angles as well as a positive correlation with the degree of condylar length. The inclined posture likely brings decreased interincisal and conical angles, associated with an increased condylar length.

The maximal lateral deviation is correlated with the degree of conic angle and has an opposite correlation with the degree of the mandibular base plane and the lower facial height. The degree of the conical angle increases in line with the degree of the lateral deviation of the spine, while the degree of the lower facial height and the mandibular base plane are in opposite correlation therewith.

The surface rotational amplitude shows negative correlation with the ramus position and the mandibular base plane, and positive correlation with the lower facial height. The increase of the degree of vertebral rotation being present at the level of main scoliotic curvature is

associated with the decreased mandibular base plane, the post-located mandible and the increased lower facial height.

The lateral amplitude shows correlation with the lower facial height, higher values of the lower facial height are associated with the increasing distance between the deviations of the two-direction spinal curvatures.

## CONCLUSIONS

The close correlation between certain postural disorders and dentofacial deviations was proved by several examination methods. These are independently confirmed by the similar correlations experienced during the examinations of patients having developed spinal deformities. The same results obtained from the applied different examination methods made possible to get to know the dentofacial features characteristic of the examined spinal deformities and to collect the main features thereof.

The facial asymmetry considered as the main feature of the extraoral appearance of the children with spinal deformities was more frequent among children suffering from M. Scheuermann than among scoliotic children, where the direction of the facial scoliotic curvature correlates with the direction of the main spinal curvature. A skeletal component playing important role in developing and sustaining facial asymmetries, the lateral positional disorder of the mandible – in line with the experience in the case of soft tissues – frequently shows correlation with the direction of the spinal curvature in the frontal plane. The basis of the facial asymmetries being more frequent among children suffering from Scheuermann's disease are the mandibular rami with significantly different length, grounding this by the presence of the mandibular asymmetry indices in every region. As a result of the functional examinations the correlations between the presence, degree and direction of mentum deviation registered during mouth opening and the spinal deformities were justified, as a functional consequence of the structural deviations described earlier. The inclination of the maxillary plane seemed the considerable deviation at the level of the maxilla, which serves as the skeletal basis of the facial scoliosis at the level of the middle third and similarly shows correlation with the direction of the main spinal curvature. Due to the various registration processes the deviation of the dental midlines does not show an organic picture. But the degree of the deviation of the two midlines compared to each other was the highest unanimously among the children with scoliosis. Out of the transversal differences of the lateral teeth, again the larger asymmetry variables were characteristic of the scoliotic group. The majority of the unilateral crossbite cases were from this latter group of spinal deformities.

Out of the vertical skeletal features – besides the already detailed mandibular variables – the lower and the entire facial heights play significant role, through their low values that are characteristic of the scoliotic children. In the case of this patient group the frequent presence of the dental deep bite is closely linked with this; these values, however, remain below those of the Scheuermann group.

The presence of the sagittal dental deviation in the frontal region – similarly to the patients with Scheuermann's disease – is more frequent, and similarly to the former deviation, it becomes more severe in line with the orthopaedic deviation. Sagittal skeletal deviations are characteristic of both groups, but – though the difference is slight – at the scoliotic children the maxilla is positioned farther while the mandible is positioned further compared to children suffering from Scheuermann's disease.

And finally it is worth mentioning the incidence values of the noises registered during the examination of the temporomandibular joint, which are high among the scoliotic children. The wide range of the examination methods for the individual features makes possible to choose simply implementable non-invasive examination methods enabling to explore the given deviations at an early stage and in an interdisciplinary way. The skeletal basis of the postural disorders developing at the same age as well as the early recognition of the dentofacial deviations showing close correlation therewith should mean the necessity of examining the potentially present joint deviations for the specialists of both fields. The existing analysing methods and the ones to be introduced are certainly suitable for recognising the features of the detailed dentofacial character.

## LIST OF OWN PUBLICATIONS

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