

ABSTRACTS

OF LECTURES

(Poster presentations will appear in the October issue of the Journal)

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1 LATERAL CEPHALOMETRIC EVALUATION OF NASAL CAVITY DEVELOPMENT IN CLEFT CHILDREN

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AIM: To investigate the long-term development of the nasal cavity, in parameters measured on lateral cephalometric radiographs, in children with clefts treated with a commonly used orthodontic and surgical protocol.

SUBJECTS: The sample investigated consisted of 48 Caucasians, divided in to four groups, as follows:

- Group A: Cleft palate, 11 subjects (3 males, 8 females)
- Group B: Left unilateral cleft lip and cleft palate–4 females
- Group C: Right unilateral cleft lip and cleft palate, 18 patients (9 males, 9 females).
- Group D: Bilateral cleft lip and cleft palate, 15 persons (9 males, 6 females).
- Controls: 9 Caucasians (4 males, 5 females) exhibiting Class I malocclusions, treated with extraction of four premolars, were matched with the study group for age and sex.

METHODS: All cleft children were treated with the same surgical and orthodontic protocol. Lateral cephalometric radiographs were taken once before orthodontic treatment at age 7–11, and once after completion of treatment at 12–16 years. Six landmarks on the lateral cephalometric radiograph were identified from which 10 measurements, including the anterior cranial and nasal floor length and the nasal cavity height and surface area, were taken. Paired *t*-tests were performed.

RESULTS: There was a tendency to retarded development of the nasal cavity in all subjects in relation to the controls which was more exaggerated in the younger age groups; the depth of the roof, the anteroposterior and the vertical dimension of the nasomaxillary complex were smaller in the cleft patients in both age groups; the surface area of the whole nasal cavity was smaller in all types of clefts in both age groups; and the developmental difference of the nasal cavity between subjects with clefts and controls was more exaggerated in girls than in boys.

CONCLUSIONS: Children with clefts treated with a commonly used orthodontic-surgical protocol exhibit altered developmental potential of their nasal cavity.

2 THE NEUROMUSCULAR SYSTEM AND ITS SIGNIFICANCE FOR OROFACIAL ANOMALIES AND THEIR TREATMENT

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AIMS: The mature nervous system is precisely wired to process sensory information into coherent patterns of activity that form the basis of our perception, thoughts, and

actions. This precise wiring is not fully developed at birth. The pattern of connections that emerges as a result of cell recognition events during prenatal development only approximates the final wiring. This initially coarse pattern of connections is subsequently refined by activity-dependent mechanisms that match precisely the presynaptic neurons to their appropriate target cells. The postnatal development depends on specific interactions between the organism and its environment, for example synaptic connections with muscles. In addition it is now known that some of the molecules involved in the survival of neurons after injury may be the same as those needed by immature neurons as they develop. Studies on neural development have identified several neurotrophic factors that are released by the targets of neurons (for example, muscles: neurotrophin-3) and which trigger biochemical changes in the neuron that are important for its survival and growth.

CONCLUSIONS: The neuromuscular system is important not only for the movements and posture of the tongue, mandible, and muscles of mastication, but also for orofacial treatment because it connects receptors which transport uninterrupted information to the central nervous system. There the information is used for three main functions: sensation, control of movement, and maintaining arousal. In addition to stimulation there is a retrograde axonal transport (from periphery to central nervous system) of neurotrophic factors (Greek 'trophos', food). It means that therapy of the orofacial neuromuscular system produces not only sensory information but also a form of nutrition for the neurons. It allows the growth of neurons and synaptic connections between neurons in the normal development and after injury.

3 THIN-PLATE SPLINE ANALYSIS OF SKELETAL CHANGES INDUCED BY FACE MASK THERAPY

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AIM: To evaluate craniofacial shape/size changes by means of thin-plate spline analysis in Class III children treated with rapid maxillary expansion and a face mask, in order to define optimum timing for this type of therapy.

SUBJECTS: A treated group of 46 subjects (26 females, 20 males) was divided into two subgroups according to the stage of dental development. The early-treated group consisted of 23 subjects treated in the early mixed dentition (mean age at Time 1, 6 years 9 months $\pm$ 7 months); the late-treated group included 23 subjects treated in the late mixed dentition (mean age at Time 1, 10 years 3 months $\pm$ 1 year). The mean treatment period was 11 months. A control group of 32 subjects with untreated Class III malocclusions (18 females, 14 males) was also divided into two subgroups (early control group, 17 subjects in the early mixed dentition and late control group, 15 subjects in the late mixed dentition). The control groups matched the treated groups as to race, dental stage, Class III occlusal and skeletal signs at

Time 1, and gender distribution and age at Times 1 and 2, and for the observation period.

METHODS: Craniofacial configurations were subjected to thin-plate spline analysis by contrasting the average configuration at Time 2 with the average configuration at Time 1 in both treated and control groups in the early and late mixed dentition. Statistical multivariate analysis (Hotelling's T^2 test) was applied to shape changes from Time 1 to Time 2 calculated on partial warp scores in the treated group compared with the control group at both dental stages. Centroid size changes from Times 1 to 2 in the treated group were compared with the control group (t -test) at both dental stages.

RESULTS: With regard to shape changes, face mask and rapid maxillary expansion therapy was able to produce a significant enhancement of the forward growth of the maxilla and a significantly more upward-forward direction of growth of the mandibular condyle (leading to smaller increments in mandibular total length Co-Pg) in the early-treated group when compared with the early controls. No significant craniofacial shape change was induced by late treatment. Craniofacial size was significantly affected by treatment only in the early mixed dentition.

CONCLUSIONS: Orthopaedic Class III treatment induces more favourable skeletal shape/size changes in the early mixed dentition than in the late mixed dentition.

4 THREE-DIMENSIONAL NUMERICAL SIMULATION OF ORTHODONTIC BONE REMODELLING

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AIMS: A numerical model for the prediction of orthodontic tooth movement is presented. The model is based on mechanics and allows the simulation of tooth movements through the alveolar bone over distances up to several millimetres as a result of applied orthodontic force systems. The basic concepts of the model, as well as a verification aid of five clinical examples, will be presented.

METHODS: The idealised three-dimensional Finite Element (FE) model of an upper canine and its adjacent supporting structures was automatically generated and processed in a way that the data could be taken over by the FE package COSMOS/M 1.75A. The geometry of the idealised tooth was an elliptical paraboloid, where the dimensions of the tooth at the alveolar crest corresponded to the axes of the ellipse and the root length to the height of the paraboloid. Within the FE program, displacements, stresses and strains generated in the tooth and supporting structures by an orthodontic force system were determined in non-linear calculations (material parameters of the periodontal ligament (PDL): $E_1 = 0.05$ MPa, $\epsilon = 7.5$ per cent, $E_2 = 0.22$ MPa). The strains first in the PDL and second in

the alveolar bone were used to calculate a remodelling signal for the alveolus and to automatically generate an updated FE model of the canine, the PDL and the bone. This process was repeated, thus simulating orthodontic tooth movements incrementally, with each individual step being in the range of $10\ \mu\text{m}$. The model was verified using the clinical results of five patients being treated with calibrated NiTi T-loops to achieve canine retraction.

RESULTS: Numerical results could reproduce the clinical tooth movements with deviations of 10 per cent if the strains in the PDL were used to calculate orthodontic bone remodelling. Calculating the remodelling signal from the strains in the alveolar bone resulted in significantly larger deviations (20–30 per cent).

CONCLUSIONS: Based on this model, the mechanical key stimulus initiating orthodontic tooth movement seems to be a result of the normal and the shear strains in the periodontal ligament.

5 MANDIBULAR OSTEOGENESIS USING A TOOTH-BORNE DISTRACTION DEVICE

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AIMS: Lengthening of the human mandible by gradual callus distraction has become an accepted procedure for the correction of severe mandibular deficiencies in recent years. Usually, the distraction device is fixed by pins or screws in the mandibular segments extra-orally through the skin. To avoid scars due to the adaptation of the extra-oral appliance it is the aim of many research groups to develop an intraoral distraction device. However, to-date the concept of osseous anchorage on the mandibular segments is preferred. An animal study was conducted to prove the basic applicability of a newly developed intra-oral device which is anchored on the mandibular teeth.

METHODS: The mandibles of 8 minipigs were distracted by an orthodontic device fixed to the teeth 2–7 days after bilateral osteotomy of the dentulous part. The elongation rate was 1 mm per day. After 9 days distraction was stopped at a final distance of 9 mm. The device was left in place for 6 weeks. After a further period of 6 weeks the animals were sacrificed for histological examination of the newly formed tissues at the site of the osteotomy, and to identify possible periodontal and dental side-effects.

RESULTS: Twelve weeks post-operatively complete osseous consolidation of the osteotomy sites was radiologically and histologically demonstrated. No serious negative side-effects were observed either in the periodontium or in the alveolar bone tissue surrounding the teeth that supported the device. **CONCLUSIONS:** Lengthening of the mandibular body using a tooth-borne distraction device is feasible. The results justify transferring this procedure to clinical practice in order to correct pronounced mandibular deficiencies.

6 CLINICAL COMPARISON BETWEEN A RESIN-REINFORCED GLASS IONOMER AND COMPOSITE RESIN

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AIMS: To compare the 12-month clinical performance of a resin-reinforced self-cured glass ionomer cement with a standard composite resin used for direct bonding of stainless steel brackets.

MATERIALS AND METHOD: The resin-reinforced self-cured glass ionomer cement tested was GC Fuji Ortho (GC Co.), which was compared with a standard composite resin (System 1+,Ormco). Twenty-eight patients with full fixed appliances were examined. In order to follow a split mouth design, the mouth of each patient was divided into quadrants. In 14 patients the maxillary left and the mandibular right quadrants were bonded with the glass ionomer cement and the remaining quadrants with the control composite resin. In the other 14 patients the quadrants were inverted. Enamel surfaces presenting caries, fillings or hypoplasia were excluded from the study. Four hundred and sixty-three stainless steel brackets Orthos (Ormco Co.) were evaluated: 232 brackets were bonded with System 1+, whereas the remaining 231 were bonded with GC Fuji Ortho. The teeth selected for bonding with the self-cured glass ionomer cement were cleaned with a mixture of water and pumice, using a rubber polishing cup and low speed handpiece. After rinsing the enamel surface with water to remove the polishing paste, the brackets were bonded without conditioning and without drying the enamel. GC Fuji Ortho was mixed according to the manufacturers' recommendations. A small amount of cement was placed on the bracket base and positioned onto the enamel surface with sufficient pressure to express excess adhesive, which was then removed from the margins of the base with an explorer before polymerization. The teeth selected to be bonded with System 1+ were also cleaned with pumice as described above, followed by etching with 37 per cent phosphoric acid for 60 seconds. Again, the material was handled according to the manufacturers' recommendations. The number, cause, and date of bracket failures were recorded for each adhesive over 12 months. Statistical analysis was performed by means of a paired *t*-test.

RESULTS: System 1+ recorded an overall failure rate significantly higher ($P < 0.05$) than GC Fuji Ortho. There were no statistically significant differences ($P > 0.05$) between the failure rates in the upper and lower arch for each material. In the upper arch, System 1+ showed a failure rate higher than GC Fuji Ortho, but the difference was not statistically significant ($P > 0.05$). On the other hand, in the lower arch, System 1+ exhibited a failure rate significantly higher ($P < 0.05$) than GC Fuji Ortho. Both bonding agents failed mostly at the enamel/adhesive interface, without causing any enamel damage.

CONCLUSIONS: This study shows a significant difference in failure rates of direct-bonded orthodontic brackets cemented with System 1+ compared with GC Fuji Ortho.

Therefore, resin-reinforced glass ionomer cements can be considered as alternative bonding materials, since they can be used in a wet field of operation and etching is not required.

7 VERTICAL DIMENSION AND ORTHODONTIC TREATMENT AFTER EXTRACTION OF THE FIRST MOLARS

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AIMS: To illustrate the correlation between the extraction of the first molars and the changes in the vertical dimensions of orthodontically treated subjects.

SUBJECTS AND METHODS: The study was based on the analysis of the orthodontic treatment of 25 patients whose first molars had been systematically extracted. As there was no orthodontic indication for the systematic extraction of the six-year-molars, at least one of the teeth of those patients was destroyed. The analysis of the lateral head films before and after orthodontic treatment illustrated the effects of extraction with special regard to long-term-stability. A successful treatment presupposed complete space closure and parallel roots. Furthermore, several aspects of the second molars as equivalents for the first molars are listed.

RESULTS: The systematic extraction of the first molars has significant effects on the vertical dimension. The anterior face height increased significantly after orthodontic treatment from 114.6 to 122.5 mm on average. The posterior face height increased significantly after orthodontic treatment from 73.8 to 81.8 mm on average. The overjet decreased from 5.5 to 2.5 mm, and the overbite from 5.7 to 3.6 mm. Concerning the relationship between SN-ANS-PNS, SN-GoGn and FMA-y-axis, no significant change in comparison with the beginning of treatment could be found.

CONCLUSIONS: The change in occlusal structure and stability results in good function and aesthetics. Orthodontic space closure after extraction of the first molars is indicated and possible.

8 THE INTERNATIONAL VALIDATION OF A COMBINED ORTHODONTIC INDEX FOR ASSESSING TREATMENT NEED AND OUTCOME

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AIMS: To investigate international professional perception of orthodontic treatment need and outcome, and devise indices of treatment need and outcome accordingly.

METHOD: A panel of 97 orthodontists from 9 countries were asked to give a dichotomous opinion on the need for treatment and treatment results on a diverse sample of 240 initial, and 98 treated study models. The occlusal traits in the study models were scored according to a defined numerical protocol and the scores used as variables to predict the panellists' decisions in a stepwise multiple logistic regression analysis. Two different regression analyses were

initially calculated, which were simplified by excluding the least predictive variables. The resulting expressions were used to select variables and coefficients for a single index to assess both treatment need and outcome. Cut-off values were determined by plotting specific sensitivity and overall accuracy. RESULTS: The final index expression included assessment of dental aesthetics, incisor vertical relationships, upper arch crowding, buccal segment sagittal relationship, and crossbite. When used to predict treatment need, the new index had specificity of 84.4 per cent, sensitivity of 85.2 per cent, and overall accuracy of 85 per cent. When used to predict treatment outcomes, the new index had specificity of 64.8 per cent, sensitivity of 70.1 per cent, and overall accuracy of 68.1 per cent.

CONCLUSION: A new orthodontic index, based on international orthodontic opinion, is proposed to assess treatment need and outcome.

9 DOES 'CATCH-UP' MANDIBULAR GROWTH OCCUR IN PATIENTS BORN WITH PIERRE ROBIN SEQUENCE?

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AIM: The aim of this study was to establish cephalometric standards for 5–6 year-old patients with Pierre Robin sequence and to determine whether 'catch-up' mandibular growth occurs in patients with the condition after this age, as compared with patients with isolated cleft of the palate.

SUBJECTS AND METHOD: This was a retrospective serial cephalometric study involving 96 patients (54 males, 42 females) with a history of Pierre Robin sequence (PR). The control group consisted of 50 patients (25 males, 25 females) with a history of complete (to the incisive foramen) or severe incomplete (into the hard palate) isolated clefting of the palate (CP). For all 96 patients in the PR group a lateral cephalogram was available at a mean age of 5.5 years (range 4.3 to 7.6 years). For 38 (20 males, 18 females) of those patients additional cephalograms were available at the mean ages of 10.3 years (range 9.2 to 12.3 years) and 16.8 years (range 14.6 to 20.3 years). All patients in the CP group had three cephalograms available at the following mean ages: 5.7 years (range 4.5 to 7.7 years), 10.6 years (range 9.3 to 12.6 years) and 17.0 years (range 14.3 to 23.3 years).

RESULTS: Significant differences were identified between the two groups, particularly in the size and sagittal position of the mandible, which was consistently shorter in the PR group at all three ages. Less severe differences were noted in the inclination of the palatal plane, the facial height proportions and midface depth.

CONCLUSION: Patients with a Pierre Robin sequence have a significantly smaller mandible compared with patients with isolated cleft palate, and the difference does not change (i.e. no 'catch-up' growth of the mandible occurs) after the age of 5 years.

10 OPEN BITE AND DEEP BITE ANALYSIS: A NEW REFERENCE

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AIM: To include the first four cervical vertebrae in the cephalometric analysis of vertical anomalies.

SUBJECTS: One hundred and twenty pre-treatment patients with an overbite of less than 0.5 mm and 130 patients with an overbite of 3 mm or more were selected. In addition to conventional cephalometric variables, the vertical position of the gonial angle and the chin opposite the cervical vertebrae was measured.

RESULTS: The difference in overbite between the two groups was 6 mm, fully accounted for by lower anterior face height, and the chin sliding cranio-caudally along the fourth vertebra. The maxilla was horizontally shorter, orbita was positioned lower, the first upper molar showed over-eruption, the mandible was larger, downward rotation of the corpus in the antegonial notch positioned the chin lower opposite the fourth cervical vertebra, point A and point B were farther apart, and vertical dentoalveolar height at the incisors was smaller in open bite than in deep bite cases. The vertical position of the gonial angle hardly differed.

DISCUSSION: It seems that early in the development of an open bite the chin establishes a position opposite to the lower half of the fourth cervical vertebra, where it remains. In deep bite cases at 8 years of age, the chin is positioned at the upper half of the fourth cervical vertebra, ascending to the intervertebra's space at 16 years of age.

CONCLUSION: Integration of the cervical vertebrae in cephalometric analysis provides new and valuable information.

11 COMPARISON OF TWO INTRAORAL MOLAR DISTALIZATION METHODS: MAGNETS VERSUS BIMETRIC DISTALIZATION ARCHES

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AIM: To determine the clinical and cephalometric effects of two intraoral molar distalization methods [magnets and bimetric distalization arches (BDA)], and to statistically compare the results.

SUBJECTS: Forty-nine patients exhibiting skeletal Class I, but dental Class II malocclusions, with a normal growth pattern were examined. (ANS.Me/N.Me < 55 per cent, S.Go/N.Me > 59 per cent, SN.MP < 38 degrees). Subjects without a mandibular dentoalveolar discrepancy and an IMPA of < 90 degrees were included in the study. The subjects were divided into three groups: 15 of them served as a control group (8 girls, 7 boys, mean age 13.28 years). Thirteen subjects who comprised the second group (10 girls, 3 boys, mean age of 12.33 years) were treated with samarium-cobalt

magnets. The remaining 21 subjects (15 girls, 6 boys with a mean age of 13.79 years) received BDA as described by Wilson. For anchorage protection a modified Nance appliance was prepared for the magnet group, while BDA patients received lingual arches and Class II elastics. Seventeen linear and 13 angular skeletal, dental and soft tissue measurements were made on lateral cephalograms on defined reference points. For accurate measurement of distal movement metal markers were attached to the gingival tubes of the molar bands. A Student's *t*-test was used for evaluation of intra- and inter-group differences. The method was calculated using Dahlberg's formula.

RESULTS: The molars moved significantly distally in both groups ($P < 0.001$) and also showed distal tipping ($P < 0.001$). The amount of distalization was greater in the BDA group, while the degree of distal tipping was higher in the magnet group. No molar extrusion was observed in either of the groups; on the contrary an intrusion was measured for the BDA group ($P < 0.01$). The overjet increased and the overbite decreased in the magnet group due to the significant ($P < 0.001$) protrusion of the upper incisors, where the soft tissue assessments were also significantly affected. There was an extrusion of upper incisors in the BDA group ($P < 0.001$). The occlusal plane was significantly affected in both groups: a counter-clockwise rotation in the magnet and a clockwise rotation in the BDA groups was observed.

CONCLUSIONS: No bodily movements were achieved in either group which may result in stability problems in the long-term. In spite of significant distal tipping there was no change in the vertical dimensions. There was considerable loss of anchorage in the maxillary anterior region in the magnet group, whereas this occurred in the mandibular region in the BDA group. Magnetic force promises a non-compliance therapy which eliminates failure in treatment objectives, while for a successful result with the BDA patient compliance is essential.

12 MUSCLES OF MASTICATION AND OCCLUSAL RELATIONSHIPS: AN EXPERIMENTAL ANIMAL STUDY

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AIM: The neuromuscular control of the masticatory mechanism takes place on three levels: cortical, subcortical, and local. The muscles of mastication represent the latter level. In animal experiments, the behaviour and adaptability of the masticatory muscles were investigated following alteration of the occlusal relationships through loss of supporting zones and bolus function.

MATERIALS AND METHODS: In approved animal experiments, the occlusal relationships in Wistar rats were altered: 1) on the 28th day post partum, bilateral extraction of lateral teeth produced a loss of supporting zones; 2) in

another trial series, a soft diet was fed to eliminate bolus function. Fifty-six animals per series were used, which were killed at 7 intervals on days 42, 56, 70, 84, 98, 112, and 126. A control series ran parallel to these. The dry weight of all muscles of mastication was determined and histochemical and biometric analyses of muscle fibre composition (proof of succinodehydrogenase, acetylcholinesterase, from glycogen C^{++} -ATP-ase) were carried out using biopsies at each individual time interval. Significance was tested with the Chi square test.

RESULTS: 1. For all time intervals of both trial series, a significant reduction of muscle dry weight was found, most noticeably in the masseter. 2. The muscle composition of the fast fibres type IIa (mitochondria-rich), IIb (mitochondria-poor), and TR fibres was significantly shifted in favour of the IIb fibres. At the end of the observation period, the original composition was retained. Due to their scarcity, slow type I fibres played only a small role.

CONCLUSIONS: Alterations in occlusal relationships have an effect on the structure of masticatory muscles. Due to the low demand placed on the muscles of mastication, a reduction in musculature was found. The muscle fibre types were forced to complement each other efficiently during adjustment of muscle strength, in order to adapt to the new masticatory load. The shift of the fibre spectrum in favour of glycolytic type II fibres is an indication that less masticatory strength is required under experimental conditions. This shift is accomplished by the new formation or restructuring of fibres. At the end of the observation period, the original relationships were retained, which is an indication of adaptation.

13 ACCURACY OF THE VISUAL TREATMENT OBJECTIVE FOR VERTICAL MEASUREMENTS

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AIMS: The accuracy of the short- and long-term growth forecast Visual Treatment Objective (VTO) was determined with regard to vertical measurements. Pre- and post-treatment growth was compared with the computer projected forecast.

MATERIALS AND METHOD: The pre-treatment cephalograms, orthopantomograms and casts of 90 consecutively treated growing patients were submitted for analysis ($n = 45$ for 2-year prediction, $n = 45$ for 5-year prediction). The computer-generated post-treatment forecasts were compared with the actual post-treatment cephalograms with regard to 10 vertical out of 48 cephalometric measurements. **RESULTS:** The short-term forecast showed moderately better results than the long-term forecast. Of 48 measurements, 23 were predicted correctly on the 2-year course and 20 on the 5-year course. Out of the 10 vertical measurements, 7 were predicted correctly on the 2-year course and 6 on the 5-year course. The computer was found to be accurate in predicting total facial height, lower facial height, facial axis, maxillary height, and rotation of the maxilla and mandible.

It was found to be inaccurate in predicting anterior and posterior facial height, their ratio (only accurate in short-term prediction) and the angle between corpus and condyle axes (mandibular arc).

CONCLUSION: For all measurements, the VTO was more accurate in assessing skeletal development than dental and soft-tissue changes. Among skeletal measurements, the most favourable predictive results were achieved for the configuration of the skull base. Vertical development seems to be a reliably predictable parameter, as well as treatment effects on vertical patterns. Since the VTO assesses them both sufficiently correctly, it can be recommended as a tool for diagnosis and treatment planning.

14 PREDICTION OF POSITIONAL AND MORPHOLOGICAL ROTATION OF THE MANDIBLE

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AIM: To estimate the possibility of predicting mandibular growth rotation at pubertal age on the basis of mandibular positional and/or morphological changes in the early developmental phases.

SUBJECTS AND METHODS: Thirty-eight untreated subjects (22 males, 16 females) were analysed. Lateral cephalograms of all subjects were taken at three time periods (T1, mean age 5 years 6 months $\pm$ 8 months; T2, mean age 6 years 8 months $\pm$ 9 months; T3, mean age 12 years 9 months $\pm$ 11 months). The seven structural signs of mandibular rotation according to Björk (1969) were used at T4 to divide the sample into two groups: 21 subjects with anterior mandibular rotation and 17 with posterior mandibular rotation. Mandibular changes from T1 to T2 were evaluated by means of the superimposition method on mandibular stable structures according to Björk and Skieller (1983). Nine cephalometric parameters were evaluated on superimposed tracings: two parameters for the analysis of positional mandibular rotation (changes in the inclination of the stable basicranial line and of the Nasal line), three parameters for the analysis of the remodelling at mandibular borders, four parameters for the analysis of morphological mandibular rotation (changes in the inclination of the Co-Pg line, in the inclination of the condyle, and in the width of the symphysis). Discriminant analysis (one-way analysis of variance and stepwise variable selection with F to enter, and to remove = 4) was applied to evaluate the predictability of rotational features of the mandible at T4 on the basis of mandibular positional and/or morphological changes from T1 to T2.

RESULTS: Discriminant analysis selected three predictive variables: changes in the inclination of the Co-Pg line, in the inclination of the chin tangent line, and in the symphysis width. The classification power (predictive reliability) of the three selected variables was 94.74 per cent. Unstandardized discriminant function coefficients were: CoPg1-CoPg2 degrees = 1.08762, CTL1-CTL2 degrees = -0.25132, and

SW1-SW2 mm = 1.32759 ($K = -1.69713$). The critical score was -0.17313.

CONCLUSIONS: Prediction in the early stages of mandibular growth rotation at pubertal age is permitted on the basis of morphological mandibular changes (error probability approximately 5 per cent). No prediction of mandibular growth rotation at pubertal age can be performed on the basis of positional mandibular rotation in the early developmental phases.

15 QUANTITATIVE EVALUATION OF ULTRASOUND SCANNING OF THE TONGUE DURING SWALLOWING

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AIM: Does the quantitative analysis of tongue movement and corresponding swallowing time of videotaped B-mode ultrasound images allow a significant differentiation between normal and abnormal swallowing? This investigation aimed to assess the control of the reproducibility and validity of the used measurement parameters.

SUBJECTS: Fifty-two dental students with no medical history, morphological or clinical signs of a tongue dysfunction or tongue thrust.

METHODS: Tongue position at rest and during the oral phase of swallowing a 2 ml water bolus was recorded 5 times for each subject with a 5 MHz transducer (100 degrees sector scanner) placed under the chin. A video timer recording to 0.01 seconds added a co-ordinated time code, and the ultrasound sequences were then videotaped. After a qualitative differentiation of abnormal and normal swallowing the sequences were quantitatively assessed by two investigators. Three different geometrical measurement methods were compared. Therefore the post-processing mode of the monographic unit was used for the subsequent tracing and superimposition of surface of the dorsum of the tongue. The tongue movements were examined for the extent of forward or upward movement in the displayed system of co-ordinates by superimposing the rest position with the elevation stage in the anterior, middle, and posterior part of the tongue surface. Additionally the dimension of maximal tongue movement in the median plane and the duration of the four successive stages of swallowing were measured.

RESULTS: In the qualitative selection 9 students had an abnormal and 43 a normal swallowing pattern. For one of the three measurement methods a significant difference between normal and abnormal swallowing could be demonstrated. For the dimension of maximal tongue movement in the median plane, the duration of the four successive swallowing stages, and the whole oral phase of swallowing, no significant differences could be demonstrated between normal and abnormal swallowing.

CONCLUSIONS: The integration of a simple geometric measurement of ultrasound sequences of the oral phase of swallowing allows a differentiation between normal and abnormal swallowing with high validity and reproducibility.

This simple quantitative evaluation can be recommended for longitudinal control of swallowing patterns.

16 THE NEUROMUSCULAR SYSTEM AND ITS SIGNIFICANCE FOR CLINICAL ORTHODONTICS

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AIMS: This presentation will provide an overview of why and how the total stomatognathic system is dependent on the neuromuscular environment. Abnormal perioral muscle function has been amply recognized as a deforming factor in its effect on the morphogenetic pattern creating and enhancing orofacial anomalies and jeopardizing the ultimate stability of orthodontic treatment. 'Whenever there is a struggle between muscle and bone, bone yields' (Sicher). Muscles, malformation and malocclusion are intimately related. Diagnostic acumen is essential, not only before, but during and after treatment, if we are to achieve optimal results. Our sophisticated techniques move teeth efficiently, but what about the ultimate effect of muscle forces after removal of tooth-borne appliances? Further, this same dynamic neuromuscular envelope can be utilized to enhance our therapeutic efforts, via a stimulus of the unique temporomandibular joint metabolism, enhancing growth increments and optimal direction of maxillo-mandibular basal structures. **RESUME:** Both deleterious and beneficial effects will be illustrated, with particular emphasis concerning the functional effect on the temporomandibular joint components, as demonstrated by the latest definitive research.

17 TRAINING OF OROFACIAL FUNCTIONS AND THEIR THEORETICAL FOUNDATIONS

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The aim of dentofacial orthopaedics consists, aside from growth regulation and stimulation, is elimination of habits and stable adaptation of orofacial function to the change in morphology.

PROBLEMS: Quantifying remodelling in periodontum and bone is carried out by histomorphometry and cephalograms. In comparison, the methods for objectifying and measurement of adaptation and training processes of the neuromuscular system caused by dentofacial orthopaedics are divided and contradictory. An increase or decrease of EMG activity in the case of passive (activator) or active (functional regulator) muscles are discussed just as controversially as the results of training and the optimal time for the beginning and the reasons for relapse.

THEORETICAL FOUNDATIONS: The training procedure should help to intensify the capability and force development of muscles and muscle groups. Training with

long-lasting effect for isometric and isotonic contractions is dependent on the composition of muscles from different types of fibres (fast and slow twitch), from the primary volume, from the primary length (overlapping of myofilaments), from the time needed for movement and from the growing development. Detecting methods for this output are histochemical analysis from biopsies, bioelectrical signal processing and registration of movement.

GENERAL TRAINING LESSON AND ORAL FUNCTION: Fields of application, from long-term experience, are sports physiology and education in the playing of wind instruments. The following basic knowledge is of interest:

1. Passive muscle tension is connected with a loss of force. A permanent increase of output in cases of muscle tension results in only an increase of muscle cross-section and improvement of movement frequency. This process is more time-consuming than muscle shortening.
2. Training output and force development are reduced in sportsmen during puberty because the acceleration of growth causes a passive muscle tension (see No. 1). Not until just before growth has finished can this disproportion between length and cross-section be balanced.
3. Strengthening of the orbicularis oris muscle in players of wind instruments causes a change in the anterior and posterior facial height and transversal diameter of the alveolar processes.

CONCLUSIONS: The optimal time for bone growth stimulation in Class II treatment is different from the optimum time for adaptation in the neuromuscular system. Success of muscular training and adaptation of oral function must be monitored until bone growth has finished. The passive muscle tension caused by the 'splint' effect of an activator must be followed by active muscle training. For the elimination of habits these principles also apply.

18 MANDIBULAR DYSFUNCTION IN RELATION TO OCCLUSION AND ORTHODONTIC TREATMENT

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AIMS: To study the influence of orthodontic treatment in subjects with Class II malocclusions on mandibular function, symptoms and signs of temporomandibular disorders (TMD), and to compare the same parameters in subjects with normal occlusion and in those with untreated Class II malocclusions. **SUBJECTS AND METHODS:** Three groups of adolescent girls of the same age were examined for symptoms and signs of TMD, and re-examined two years later. The groups were: 60 subjects with normal occlusion (Normal group), 59 subjects with Class II malocclusions (Class II group) without any planned orthodontics, and 64 subjects with Class II malocclusions (Orthodontic group: fixed appliance, edgewise straight wire technique) examined before and after orthodontic treatment.

RESULTS: Signs and symptoms of TMD were inconsistent over the course of time, showing both improvement and

impairment on an individual basis. The Normal group had a lower overall prevalence of symptoms and signs of TMD than the Class II group and the Orthodontic group both at the beginning and end of the study. The prevalence of signs and symptoms of TMD from the temporomandibular joint was without statistical change in any of the groups. In the Orthodontic group the prevalence of signs of TMD of muscular origin was significantly less common after treatment than before ($P = 0.009$, Wilcoxon matched pairs signed rank test) while the Normal and Class II groups showed minor changes. The prevalence of non-working side interferences decreased significantly in the Orthodontic group ($P = 0.01$, Wilcoxon) but remained the same in the other groups.

CONCLUSIONS: It is concluded that subjects with Class II malocclusions and signs of TMD of muscular origin seem to benefit functionally from orthodontic treatment of their malocclusions in a two year perspective. The Normal group appear to have a lower risk for symptoms and signs of TMD than the untreated Class II malocclusion group.

19 ORTHODONTIC TREATMENT OF COMPENSATED AND NON-COMPENSATED HIGH ANGLE MALOCCLUSIONS

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AIM: To assess the effect of orthodontic treatment on the dentoskeletal morphology in 'high angle' malocclusions with special reference to overbite correction.

SUBJECTS: From the total patient material of 191 children with a hyperdivergent ('high angle') mandibular plane ($ML/NSL \geq 40$ degrees), 54 patients in the mixed dentition were included in the study.

METHOD: Pre- and post-treatment lateral headfilms of each patient were analysed. The subjects were divided into three subgroups according to the amount of pre-treatment overbite as a compensation measure of the jaw base hyperdivergency: overbite < 0 mm = insufficient/no compensation; overbite 0–4 mm = acceptable compensation; overbite > 4 mm = over-compensation.

RESULTS: In 20 per cent of the 'high angle' cases an insufficient dentoskeletal compensation (overbite < 0 mm) existed pre-treatment. In 45 per cent of the subjects an acceptable compensation (overbite 0–4 mm), and in 35 per cent an over-compensation (overbite > 4 mm) could be recorded. In the insufficient/no compensation group orthodontic treatment resulted in a significant increase of the overbite ($P < 0.001$). In 82 per cent of the cases the open bite was corrected. In the over-compensation group a significant decrease of the overbite ($P < 0.001$) was found. The deep bite was corrected in 90 per cent of the cases. Overbite correction (open and deep bite) was the result of changes in the inclination of the upper and lower occlusal planes. The mandibular plane angle was not affected by treatment.

CONCLUSION: Orthodontic overbite correction in compensated (deep bite) and non-compensated (open bite) 'high

angle' malocclusions is accomplished without influencing the mandibular plane angle.

20 INFLUENCE OF TONGUE THRUST ON THE VARIABILITY OF SPEAKING MOVEMENT

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INTRODUCTION: Malfunctions of the tongue are reported to be of major aetiological significance in the development of speech disorders and malocclusions. The aim of this study was to compare the variability of tongue movements during speaking sequences to find objective parameters for the diagnosis of tongue thrust.

SUBJECTS AND METHOD: Thirty-one subjects aged 14.3 to 37.3 years with and without the diagnosis of tongue thrust were monitored during five repetitions of vowel-consonant-vowel utterances. The registration of the tongue movement took place with an 'Articulograph AG 100®' (Carstens Medizinelektronik Co.). The variability of geometric and time variables of tongue movement were analysed in subjects with and without the diagnosis of tongue thrust.

RESULTS: The statistical analysis of the speaking sequences proved that subjects with a diagnosis of tongue thrust showed less variability of tongue movements with regard to different time intervals than subjects with normal swallowing. Concerning geometric variables, significant differences were found between both groups. These differences were most noticeable during upward movement of the tongue after the first vocal.

CONCLUSION: The analysis of spatial and time intervals of articulatory movements by use of electromagnetic articulography offers the opportunity for an objective diagnosis of tongue thrust, and permits evaluation of the changes in tongue movement during myofunctional or orthodontic therapy.

21 MASSETER MUSCLE: AN INNOCENT VICTIM OR PRIME SUSPECT IN LONG FACE DEFORMITY?

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AIMS: Vertical facial deformity is associated with functional and structural changes within the masseter muscle. Measures of occlusal force are markedly reduced in long face patients (LFS) compared with their normal counterparts. Similarly, histochemically stained sections demonstrate that the fast fibres are consistently reduced both in cross-sectional area and in their relative prevalence in LFS subjects. Whether these changes are secondary to an inefficient masticatory system, or are of primary aetiological origin is difficult to ascertain. The aim of this presentation is to summarize the

results of several investigations designed to study the structure of the masseter muscle at the molecular level in normal and LFS individuals, thus providing further evidence to answer the cause or effect conundrum.

MATERIALS: Biopsies from 23 adult patients undergoing orthognathic surgery for correction of a long face deformity, 14 control patients with normal vertical facial form and 5 specimens from somatic muscle were analysed for fibre morphology, myosin heavy chain (MHC) isoform gene expression and fibronectin content.

RESULTS: Masseter muscle differed from somatic skeletal muscle in the range of MHC isoforms expressed and there was a significant variation in the amount of perinatal and IIx isoforms expressed in the LFS compared with the normal counterparts. Fibronectin content was significantly increased in the LFS group. These results do not conform to the changes which can be induced under experimental conditions as a result of either overloading or disuse of a muscle.

CONCLUSIONS: Whilst it is appreciated that further studies need to be undertaken before definite conclusions can be made, these results point towards the structural changes in masseter muscle of LFS patients being a reflection of an underlying primary myopathy rather than a response to functional requirements.

22 INFLUENCE OF MUSCLE VOLUME ON TEMPOROMANDIBULAR FUNCTION IN CONDYLAR DYSPLASIA PATIENTS

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AIMS: To evaluate the effect of unilateral reduced masticatory muscle volume on temporomandibular joint (TMJ) function.

SUBJECTS AND METHOD: The study was undertaken on seven patients between 5 and 12 years of age, suffering from different types of mandibular dysostosis who were treated functionally with an activator. The patients were examined clinically by muscular palpation, and by means of an electronic axiograph, and radiologically using spiral computed tomography. The measurements were made on the axiographic tracings and the range, the angle and the consistency of maximal protrusion, retrusion, opening and closing movements as well as lateral excursions were recorded. From axial CT-scans paracoronal, parasagittal and 3D-images were constructed using the standard and 3D-Siemens construction software and were analysed to assess condylar formation and deficiency. Soft tissue CT-images were used to measure volumes and densities of the masticatory muscles.

RESULTS: Comparison of the lateral pterygoid muscle volume at the beginning and during functional treatment showed that muscle volume increased bilaterally but not symmetrically. The clinical and axiographic examination revealed a strong correlation between muscular volume and condylar activity. Although most volumes of the lateral pterygoid muscles on the affected side were smaller than

those of the contralateral counterparts, mandibular movements were rather symmetrical, but less consistent.

CONCLUSIONS: Significant improvement of mandibular excursions and occlusion suggest the early repositioning of the TMJ by functional appliances in a symmetrical position. This is essential to normalize the growth potential of the TMJ structures and to gain soft and hard tissue adaptation which is supported primarily by muscular volume increase, and secondly by an increase of condylar neck length and width, respectively modelling or remodelling of the lacking or dysplastic condylar head.

23 RETENTION REGIMES: A CONSENSUS?

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AIMS: In order to audit views on the treatment of 6 patients with a range of orthodontic problems and to establish whether or not there was agreement with regard to 'best practice', pre-treatment records and questionnaires were circulated to United Kingdom orthodontists in hospital and specialist practice. Four questions related to retention procedures. Returns were received from 433 orthodontists.

RESULTS:

1. A range of lengths of retention was proposed for each case. Some consensus existed in three cases, whilst no consensus existed for the remaining cases.
2. Upper removable retainers were most popular. Lower removable retainers were more popular than lower fixed retainers.
3. There were marked regional variations with regard to the type of lower retention preferred.

CONCLUSIONS: There is little consensus as to 'best practice' as it relates to orthodontic retention. There is also evidence of a regional bias which may reflect the teaching at the various orthodontic training institutions in the United Kingdom.

24 MASSETER MUSCLE THICKNESS AND TREATMENT EFFICIENCY OF FUNCTIONAL APPLIANCES

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AIMS: The use of functional appliances in the treatment of Angle Class II malocclusions is based on the tension they exert on the teeth and the bone structures, either due to muscle contraction or to the viscoelastic property of the muscles. The tension applied by a muscle during contraction, as well as the viscoelastic property of the muscle, is directly related to the thickness of the muscle. Thus, the thickness of the masticatory muscles may be an important functional factor in the treatment of skeletal discrepancies with functional appliances. The aim of this investigation was to

estimate the influence of the initial thickness of the masseter in the treatment efficiency of functional appliances, as well as the effect of this treatment on masseter muscle thickness.

SUBJECTS AND METHODS: Twenty children, 8–11 years of age, with skeletal distal occlusion and large overjets were treated with Twinblocks. The duration of the treatment period was 10 to 14 months. Dental casts, lateral cephalograms, and ultrasonographic measurements of the masseter muscle and body height were performed before and after treatment.

RESULTS: At the end of the treatment period, reduction of the increased overjet and normalization of the occlusion were observed. The masseter thickness was thinner at the end of treatment. Proclination of the lower incisors was observed at the end of treatment, being more pronounced in individuals with thinner muscles.

CONCLUSIONS: Treatment of distal occlusion with functional appliances (Twinblock) decreased the functional activity of masticatory muscles which led to mild atrophy of the masseter. The initial condition of the muscles, estimated by the thickness of masseter, may influence the proclination of the lower incisors. Thick masticatory muscles may increase the 'anchorage' of the lower dentition due to greater masticatory forces.

25 THE SELLA TURCICA IN CHILDREN WITH SPINA BIFIDA.

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AIMS: The sella turcica region is the subject of attention in orthodontic cephalometric analysis, as the placing of the cephalometric point (S, Sella) in the centre of the sella turcica is essential for the results of cephalometric measurements. The problem in this connection is that deviant morphology of the sella turcica is a frequent finding, but very little attention has been paid in the scientific literature to systematizing these deviations. The purpose of the present study was to analyse the morphology of the sella turcica in children born with spina bifida. Profile radiographs from 16 children (9 females, 7 males) born with spina bifida were analysed.

RESULTS: The contour of the anterior wall of the sella turcica in spina bifida patients, instead of following the normal cranio-caudal direction, was always in an obliquely antero-posterior direction. The sella turcica thus appeared broad cranially with a diverging anterior wall, or with both diverging anterior and posterior walls. This appearance gave an impression of a wide sella turcica with less depth than normal in spina bifida patients.

CONCLUSIONS: The present study has drawn attention to the fact that congenital malformations in the axial skeleton,

even though as in the case of spina bifida they are located far from the cranial base, also manifest themselves in the cranial base. The pathogenetic relationship between these manifestations is to be found in the early embryonic structure, the notochord. With the concept of embryological developmental fields, defined as areas with a common developmental origin, such as the notochord field involved in spina bifida, new ways seem to be emerging for an improvement in aetiologically-based diagnosis and treatment.

26 LOWER LIP ACTIVITY AND FORCES WITH THE LIP BUMPER

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SUBJECTS AND METHODS: Lower lip activity was measured with surface electromyography on an adolescent sample of 25 patients before and after 12 months of treatment with the mandibular lip bumper. Simultaneously, strain gauges at the anchor molars measured forces exerted on these teeth by the bumper. Recordings included speech, swallowing, and a closed lip rest position.

RESULTS: Means for lower lip activity were generally higher with the lip bumper in place, ranging from 13.78 µg for the closed lip position to 52.64 µg when speaking the word 'phone'. Mean force measurements ranged from 12.71 grams for the closed lip rest position to 35.04 grams for swallowing. The comparison of pre- and post-treatment measurements did not show statistically significant (*t*-test, $P < 0.05$) differences for lower lip activity and forces. The strongest correlation between lower lip activity and forces was found for swallowing ($P < 0.05$, $r = 0.46-0.74$), while correlations for speech and the closed lip rest position were variable.

CONCLUSIONS: Lip bumper treatment does not change the levels of lower lip activity or forces for the functional exercises investigated. The results of these measurements do not indicate adaptation of the lower lip to the appliance. It is suggested that muscle activity of the lower lip is one of the factors resulting in forces on the lip bumper at the molars, but other factors such as unrecorded muscle activity and tonic elasticity of the soft tissue also contribute to the actual force values measured at the mandibular molars.

27 STABILITY OF OCCLUSAL TREATMENT OUTCOME 10 YEARS POST-RETENTION

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AIM: Kahl-Nieke *et al.* (1996) emphasized that 'the review of the literature points out the need for a quantitative and qualitative assessment of post-treatment changes by using a sample that is large enough for statistical analysis consisting of cases out of retention for at least 10 years'. At the University of Nijmegen, The Netherlands, such a large sample is available (more than 2000 cases). The aim of this study was

to evaluate long-term post-treatment occlusal outcome until 10 years post-retention utilizing the PAR Index.

METHODS: Dental casts of 2368 patients were evaluated. The PAR Index was measured at the pre-treatment stage, directly post-treatment, post-retention, and 2, 5 and 10 years post-retention. Three observers were incorporated in this study. The intra- and inter-observer agreement were determined by double determination of 36 dental casts. The mean absolute change, as well as the percentage change per year (relapse) related to the post-retention stage, was calculated. ANOVA was applied to compare the mean change in the PAR between cases with and without a fixed retainer at the post-retention stage and up to 10 years post-retention.

RESULTS: The mean initial PAR score was 27.2 (sd 10.0) and this score dropped to 7.7 (s.d. 6.1) as a result of orthodontic treatment. Ten years post-retention 64 per cent of the orthodontic treatment result was maintained. Most of the relapse (38 per cent) took place during the first two years after retention. Subjects where retention finished earlier than 15 (female) or 16 (male) years of age showed more relapse. All occlusal traits relapsed gradually over time but remained stable at later stages, except the lower contact point displacement which showed a fast and continuous increase.

CONCLUSIONS: It should be more commonly considered to maintain retainers if some growth is still expected. Furthermore, all patients should be informed prior to treatment about treatment limitations in order to better meet their expectations.

Kahl-Nieke B, Fischbach H, Schwarze C W 1996 Treatment and post-treatment changes in dental arch dimensions: A long-term evaluation of influencing co-factors. *American Journal of Orthodontics and Dentofacial Orthopedics* 109: 368–378

28 DEVELOPMENT OF OVERBITE AND VERTICAL FACIAL DIMENSIONS DURING AND AFTER ORTHODONTIC TREATMENT

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AIMS: Investigation of the development and facial dimensions during and after treatment.

MATERIALS AND METHOD: In this retrospective study, lateral cephalograms of 220 children taken before (mean age 11.0 ± 1.2 years), and after active orthodontic treatment (mean age 14.8 ± 0.6 years) and at least 13 years post-retention (mean age 26 ± 4.4 years) were evaluated. The development of the overbite was compared with the development of several skeletal and dental measurements.

RESULTS: In 21 per cent of the patients showing a normal overbite before and after treatment, post-treatment changes in overbite were observed. Of the patients with a deep bite before treatment, 33 per cent showed complete relapse and 2 per cent showed a post-treatment development into an end-to-end occlusion. Of the patients with an open bite pre-treatment, none showed a complete relapse but 44 per cent relapsed towards an end-to-end occlusion and

one individual developed a deep bite. Intra-individual changes in vertical facial dimensions after treatment were observed in 18 per cent of the males and 13 per cent of the females. The development of the overbite showed some association with the development of the palatomandibular angle (only in the female group), with changes in the inclination of the lower incisors and with the development of the lower incisal height. **CONCLUSIONS:** Considerable changes in vertical dimensions and in the overbite may occur after treatment. The overbite development appears to be independent of that of the lower face height during and after treatment but is influenced by changes in the inclination of the lower incisors. Excessive development of the mandibular incisal height during treatment may enhance some degree of relapse of the pre-treatment overbite.

29 FINISHING OCCLUSION AND LONG-TERM ORTHODONTIC STABILITY

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AIM: To determine whether long-term post-treatment occlusal stability can be predicted on the basis of the standard of occlusal finish at the end of active treatment.

SUBJECTS AND METHOD: The occlusions of 65 patients, treated by one experienced orthodontist with consistent philosophy and goals, were assessed according to the PAR Index. For each patient, pre-, post-treatment and long-term follow-up models were assessed. The mean follow-up period was 130 months. Mean weighted PAR scores were calculated for the total sample and various sub-groups at each stage. Mean percentage changes in weighted PAR scores were also calculated. The relationships between the occlusal standards at the end of active treatment and at the end of the follow-up period and specific diagnostic and treatment factors were then investigated to search for any factors which might be predictive of long-term post-treatment occlusal stability or instability.

RESULTS AND CONCLUSIONS: The overall mean weighted pre-, post-treatment and follow-up PAR scores were 25.5, 3.0 and 7.0, respectively. There was an 85.6 per cent decrease with treatment in the overall mean weighted PAR score. This was followed by a 15.2 per cent increase in that overall mean during the follow-up period. Neither the standard of occlusal finish at the end of active treatment, nor any of the other specific diagnostic and treatment factors tested in this study were found to be predictive of long-term occlusal stability or instability.

30 MUSCLE LESIONS IN SLEEP APNOEA—A CAUSE OR A CONSEQUENCE?

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AIMS: The patency of the upper airway is dependent on the functional activity of the hyoid and palato-pharyngeal muscles. The aim of the present study was to investigate

whether neuromuscular dysfunction could be a cause of airway collapse in these patients.

MATERIALS AND METHOD: Samples from the palato-pharyngeus and uvula muscles of 11 subjects suffering from heavy snoring and sleep apnoea were obtained and analysed using enzyme and immunohistochemical techniques and compared with corresponding muscle samples from 5 reference subjects.

RESULTS: Statistically significant alterations ($P < 0.05$) in the muscle morphology were present in the samples from the patient group. An abnormal variability in fibre size, an aberrant inter-myofibrillar structure, and capillary changes were the most striking findings.

CONCLUSION: A marked and significant pathological muscle morphology was present in the samples from the palato-pharyngeal muscles of the patients. These changes suggest that a neuromuscular dysfunction of the upper airway muscles is present possibly causing airway collapse. These changes in muscle morphology could be a primary cause of the obstruction, or secondary changes as a consequence of vibratory trauma due to heavy snoring.

31 BIOMECHANICAL CONSIDERATION OF THE CAUSE OF POST-NATAL JAW DEFORMITY

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AIMS: It is well known that postnatal 'jaw deformities' can be caused by disharmony of the masticatory system. The purpose of this study was to clarify the mechanism of mandibular deformation using bone density measurement and biomechanical analysis.

METHODS: Three-dimensional skeletal morphology, distribution of bone density and mechanical stress generated by muscle loading were determined using Quantitative Computed Tomography (3D-QCT) and Finite Element Analysis (3D-FEA). (Maki *et al.*, 1997). Thirty-seven individuals with skeletal deformity and 12 normal subjects (6 to 27 years of age) were evaluated. The study received ethical approval from Showa University and informed consent was obtained from each patient.

RESULTS: In comparison with normal individuals, most subjects with deformed mandibles under 18 years of age showed deviations of high-density which coincided with the morphological displacement. However, in subjects more than 20 years of age, high-density areas were ranged symmetrically against the morphological deformation. In all subjects, the distribution of equivalent (von Mises) stress generated by muscle loading coincided with the area of high density.

CONCLUSIONS: Based on the above comparison it was found that mechanical stress generated by masticatory muscles affects the distribution of mandibular bone density and leads to morphological changes in growth. The functional interferences

generate the imbalance in stress at an early stage. Condylar growth is aimed at eliminating the imbalance. As a result of asymmetrical condylar growth, morphological deformity appears. After condylar growth is complete, bone density adapts to a balanced condition. These findings suggest that early preventive orthodontic treatment gives successful results.

Maki K, Okano T, Morohashi T, Yamada T, Shibasaki Y 1997 The application of three-dimensional quantitative computed tomography to the maxillofacial skeleton. *Dentomaxillofacial Radiology* 26: 39–44

32 MUSCLE PAIN AND FACTORS AFFECTING PRESSURE PAIN THRESHOLDS OF THE JAW MUSCLES

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Disorders of the masticatory muscles are a major cause of pain of non-dental origin in the orofacial region. This pain is defined as a dull, aching, continuous but variable pain that commonly increases with function and should be considered as a social health problem due to the high prevalence in the general population. Although the primary aetiopathology of masticatory pain is still largely unknown, several pathogenetic mechanisms have been suggested, including muscle hyperactivity, occlusal disturbances and psychological factors. An interplay of peripheral and central phenomena could account for both the tenderness to palpation and pain on movement which is found clinically. Palpatory tenderness of muscle remains the essential element of diagnostic significance when dealing with muscle pain. Recent evidence suggests that the evaluation of muscle tenderness may be enhanced by the use of a pressure algometer which appears more objective and reliable than manual palpation. Pressure pain threshold (PPT) can be defined as the amount of applied pressure necessary for a subject to report the onset of pain.

A series of studies were carried out in order to investigate the effects of some experimental factors on PPT of the jaw muscles. These included orthodontic pain, psychological stress, prolonged static and dynamic activity of the jaw muscles and the stage of menstruation. The findings suggest that PPT of the jaw muscles may be affected by both central and peripheral factors and support the multifactorial model to explain the aetiology of muscle pain disorders.

33 RELATIONSHIP BETWEEN THE VOLUME OF MASTICATORY MUSCLES AND DENTOFACIAL MORPHOLOGY

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AIMS: Sanjo (1997) and Kubota *et al.* (1998) have previously reported that the thickness of the masseter muscle, examined

by ultrasonographic scanning, closely relates to the mandibular bone shape. The aim of this study was to clarify the relationship between masticatory muscle volume and the size and shape of jaw bones.

SUBJECTS AND METHOD: The subjects were 61 adult volunteers (43 males, 18 females with mean ages of 24 years 4 months and 23 years 2 months, respectively). The volume of each lateral and medial pterygoid and masseter muscle was measured and calculated by computer on the 7 to 21 frames of CT images which were scanned horizontally from the FH plane to the mandibular border at intervals of 2 to 5 mm. The dentofacial morphology was measured by tracings from lateral roentgenograms. The obtained data were examined using Pearson's correlation coefficients matrix.

RESULTS: The mean volumes in each muscle were 34.86 cm³ for the masseter, 19.65 cm³ and 10.96 cm³ for both lateral and medial pterygoid muscles, respectively. The results from correlation coefficients, mandibular ramus and body height of the molar region, relate to the medial pterygoid muscle volumes ($P < 0.005$). The volume of masseter muscle on the CT scans was correlated with the thickness measured by ultrasonography ($P < 0.05$).

CONCLUSIONS: Masticatory muscle volume influences the development and formation of the posterior area of the mandible.

Sanjo I 1997 Relationship between masticatory ability and dentofacial structure in children. Dental Journal of Iwate Medical University 22: 12–25 (in Japanese)

Kubota M, Nakano H, Sanjo I, Satoh K, Sanjo T, Kamegai T, Ishikawa F 1998 Relationship between maxillofacial morphology and masseter muscle thickness in adults. European Journal of Orthodontics (in press)

34 FHL mRNA EXPRESSION IN THE MASSETER MUSCLE OF DYSTROPHIC MICE

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The craniofacial musculature is intricately involved in the development of facial form. The hypothesis that vertical facial deformities may arise from an aberrant muscle phenotype is being investigated. Indeed certain muscular dystrophies have been associated with altered vertical facial form. Consequently a number of muscle specific molecular markers are being examined.

FHL-1 and FHL-3 are both expressed in skeletal muscle and belong to a family of structurally similar LIM-proteins. LIM-proteins are defined by the presence of one or more double zinc-finger domains. Those LIM-proteins that have been characterized appear to be involved in areas of development and differentiation and have been implicated in cytoskeletal remodelling and transcriptional regulation. The precise role

of the FHL family is unknown, however elevated FHL-1 expression has been associated with postnatal muscle growth. **AIMS:** (1) to compare the mRNA expression of FHL-1 and FHL-3 in the masseter with a wide variety of normal murine tissues, and (2) to investigate the mRNA expression in the masseter and the muscles of the crus from dystrophin deficient MDX mice.

RESULTS: The elevated expression of FHL-1 and FHL-3 in skeletal muscles versus other tissues was confirmed and a relatively high expression of FHL-3 in the masseter and tongue was observed in somatically derived muscles. There were significant differences in the expression of FHL-1 and FHL-3 in the masseter of one month postnatal MDX mice compared with the control C57/B110 strain of normal mice, but this difference was not observed three months postnatally.

CONCLUSIONS: It is at one month that the masseter enters a degenerative/regenerative crisis characteristic of the dystrophy. This suggests that FHL-1 and FHL-3 expression may be useful indicators of a dystrophic muscle phenotype and may aid in the appreciation of the aetiology of vertical facial deformity.

35 A NEW METHOD FOR THE ANALYSIS OF THE FACE IN THREE DIMENSIONS USING A SYSTEM OF SHAPE ANALYSIS

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AIMS: The aim of the investigation was to develop a mathematical system to define the shape of the surface of the face in three dimensions and to break it down into its component parts.

There are many systems available to produce co-ordinates of the face in three dimensions, but the difficulties arise due to the inability to adequately analyse the data. Coombes *et al.* (1991) described a mathematical system of analysis which could define any object in terms of eight basic shapes, peaks, pits, ridges, valleys, saddle ridges, saddle valleys, minimal curvatures and flat surfaces. They used these mathematically defined surfaces and developed a method of analysis which has been used to demonstrate the changes in the surface of the face following surgery. This programme has been further developed and it is now possible to separate the various shapes and overlay them over the facial surface thus identifying the areas that correspond to that particular shape.

The programme has been applied to a series of 331 patients aged 5–18 years with normal development of the face, who had been optically surfaced scanned. Each of the age groups were divided into males and females and the scans averaged. The results indicate that the face grows asymmetrically from the age of 9 years and that although the asymmetry is on one side, future growth is asymmetrical on the other side and the final result is symmetry. There are also ages when the face shows no growth but a reduction in size just prior to a growth spurt.

CONCLUSIONS: Normal growth of the face is not symmetrical. Therefore analysis of abnormal growth of the face needs to be undertaken with care taking into account these variations.

Coombes A M, Linney A D, Moss J P, Richards R 1991 A method for the analysis of the 3D shape of the face and changes in the shape brought about by facial surgery. In: Heron R E (ed) *Biostereometrics technology and applications*. Proceedings of SPIE 1380: 180–189

36 GROWTH CONSIDERATIONS IN PATIENTS WITH VERTICAL FACIAL PATTERNS

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KEYNOTE ADDRESS

Patients with a vertical facial pattern exhibit disproportionately long, lower, and total anterior face heights. These patients are dolichofacial with a high mandibular plane angle. Clinical management of malocclusions in these patients is more difficult due to the potential open bite tendencies. Biomechanically, faces with vertical discrepancy are at a disadvantage since most orthodontic mechanics are extrusive in nature. Extrusion of molars further increases the vertical height with a resulting posterior rotation of the mandible. The dentitions are harder to retain as modification and control of the growth pattern must be maintained until completion of facial growth. Knowledge of growth patterns and timings in these individuals will allow us to intervene and modify growth to optimize the dentofacial relationships. Longitudinal growth studies have shown that the discrepancy lies in the anterior dimensions of the face. The growth in posterior facial height does not significantly differ in long or short face individuals. Excessive dentoalveolar growth in the molar region exacerbates the vertical effects. Since the vertical pattern is established as early as 7 years of age, it is suggested that early treatment be initiated to control the vertical dentoalveolar growth. The maturational pattern of patients with vertical dysplasias shows earlier onset of the adolescent growth spurt in contrast with short face patients. The growth changes in the thickness and length of the lips are larger in patients with long faces. The male sample shows larger lip changes both in thickness and length than the female sample. The growth of the nose is relatively less in the long faces when compared with the short face individuals.

37 OVERJET AND DENTAL TRAUMA—A META-ANALYSIS OF RISK

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AIMS: To aggregate the risk of overjet on trauma using several papers and performing a meta-analysis on the results.

In order to assess the quality of each paper, a methodological checklist for observational studies was developed.

The eleven articles, out of 26, involved in this study were identified by a literature search of Medline (1966–1996) and Excerpta Medica (1985–1996) data bases, and by a hand search using predetermined keywords and inclusion and exclusion criteria. Using raw data available in the papers, 2×2 tables for overjet versus trauma were reconstructed. Odds ratio (OR) and its confidence interval (CI) were calculated. The heterogeneity among ORs of the papers was tested and the calculated ORs were statistically pooled (Whitehead and Whitehead). Separate stratified analyses were performed in case of heterogeneity.

RESULTS: The average methodological score was 41 (maximum score was 100). Comparing two overjet groups: smaller than 3 mm and larger than 3 mm, the pooled OR was 2.30 (CI = 2.03–2.50) but the ORs were heterogeneous ($P < 0.001$). Stratified by age, pooled OR was 2.16, the heterogeneity of the results remained. Simultaneous stratification of age and studies with a methodologically higher score gave no substantial change. When data of boys and girls were separately pooled, a significant difference between the pooled ORs was found, 1.77 and 2.90 respectively. Moreover, within boys and girls the ORs were homogeneous. For overjets smaller than 3 mm and larger than 6 mm, the pooled OR without stratification was 2.63. The ORs were heterogeneous. **CONCLUSION:** Children with an overjet larger than 3 mm are more than twice at risk of trauma than children with overjets smaller than 3 mm. Boys are at a lower risk than girls in the same overjet group. Risk of sustaining trauma to anterior teeth tends to increase with increasing overjet size. The pooled OR and the heterogeneity do not seem to be affected by the quality of the studies.

38 A LONG-TERM STUDY OF 132 DECIDUOUS MOLARS WITH AGENESIS OF THE PERMANENT SUCCESSORS

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INTRODUCTION: There is no generally accepted treatment modality for deciduous molars with agenesis of permanent successors. Autotransplantation of permanent successors from other regions have been described in long-term studies (Andreasen *et al.*, 1990; Paulsen *et al.*, 1995). Other methods are orthodontic closure or maintaining deciduous molars, but how many affected areas are real targets for orthodontic intervention?

AIM: To describe changes of deciduous molars with agenesis of permanent successors in a long-term study, if possible with controls, and divide the affected teeth into groups with different development, and evaluate aetiological theories of different development.

SUBJECTS AND METHOD: Eighty-seven patients with 132 deciduous molars (119 mandibular, 13 maxillary) were consecutively included in the study from the standardized

screenings of need for the municipal orthodontic service. Standardized radiographs were taken every year, if possible, until endochondral growth had ceased. Each series of radiographs was controlled by a visual technique and measured in length by a sliding calliper, and the affected teeth were sampled in groups of changes: unchanged, surface root resorption, ankylosis (replacement root resorption), changes caused by caries sequelae and root resorption caused by eruption of a neighbouring tooth.

RESULTS: One hundred and twenty-two (92.5 per cent) of all deciduous teeth were saved at the end of the study. Sixty-two (47 per cent) showed nearly unchanged root length, 34 (26 per cent) showed ongoing surface root resorption during normal premolar eruption. All showed slight infraocclusion. Twenty-five (19 per cent) showed ankylosis accelerating at the end of puberty. Two (1.5 per cent) were lost according to caries sequelae and treated orthodontically. Two (1.5 per cent) were lost due to root resorption during eruption of a neighbouring premolar. Seven (5 per cent) with severe ankylosis were substituted with autotransplantation. Eight premolars are waiting autotransplantation of third molars from the maxilla. It seems as though early developed agenesis (genetic) will normally leave the deciduous teeth without resorptions. Otherwise, regions with later developed agenesis (environmental) will involve deciduous teeth with root resorption.

CONCLUSION: Different aetiology (genetic, environmental) is indicated as a main cause in the different development of the affected deciduous teeth. Surface resorption was ongoing during the normal eruption time of the premolars. Ankylosis was seen during puberty with aggravation after puberty. The degree of root resorption seemed to be stable at the end of growth. It is proposed to follow the development of deciduous teeth with agenesis of the successor with radiographs to detect the need for intervention.

Andreasen J O, Paulsen H U, Ahlquist R, Bayer T, Schwartz O 1990 A long term study of 370 autotransplanted premolars. *European Journal of Orthodontics* 12: 14–50

Paulsen H U, Andreasen J O, Schwartz O 1995 Pulp and periodontal healing, root development and root resorption subsequent to transplantation and orthodontic rotation. *American Journal of Orthodontics and Dentofacial Orthopedics* 108: 630–640

39 GROWTH OF A RIB GRAFT IN THE TEMPOROMANDIBULAR JOINTS OF MARMOSET MONKEYS, *CALLITHRIX JACCHUS*
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AIM: Autogenous costochondral grafts (CCG) are used to construct mandibular condylar processes in cases of condylar agenesis or destruction. From the functional and aesthetic point of view CCGs may be considered appropriate. However, predictable growth and, most frequently, overgrowth of

the condyle-ramus unit is a common consequence when CCGs are used in growing patients. Previous investigations on rats have revealed that the amount of cartilage in the rib graft has a direct bearing on its growth capacity. Nevertheless, the use of rats as experimental animals did not allow a proper examination of the effect of TMJ functioning on CCG growth. The aim of this study was to examine growth and adaptation of CCGs in the TMJ, and particularly to determine whether the amount of cartilage in the graft affects the growth of the constructed condyle-ramus unit.

MATERIALS AND METHODS: The material consisted of three growing and three adult marmoset monkeys, *Callithrix jacchus*. An autogenous rib section with either a long (4 mm) or short (1 mm) cartilaginous portion was grafted to replace the ectomized left mandibular condyle. The young animals were operated on at the age of four months and the adults at the age of 24 months. The anaesthetized animals were examined by visual observation, recording the weight and taking antero-posterior radiograms pre-operatively, one month post-operatively and thereafter, bimonthly.

RESULTS: The animals tolerated the operation well and were allowed to have a normal diet one week post-operatively. They gained weight in accordance with available growth curves. None of the animals showed any dental or facial growth aberrations during the first three post-operative months. Growing animals with a long cartilaginous graft showed a dental asymmetry five months after the operation, indicative of overgrowth of the grafted side, whereas facial and dental symmetry was maintained in the growing monkey with a short cartilaginous graft. No facial or dental asymmetries were noted in the adult animals, irrespective of the amount of cartilage in the graft.

CONCLUSION: The findings of the present intermediate evaluation can be interpreted to reveal that TMJ functioning does not have a major role in the growth regulation of CCGs. Rather, the growth of CCG seems to be affected by humoral factors as evidenced by overgrowth occurring concomitant with the pubertal growth spurt of the marmosets. In addition the findings confirm earlier conclusions that the amount of cartilage in the rib graft is of importance with respect to growth of the constructed condyle-ramus unit in growing animals, whereas this is not the case in non-growing animals.

40 ELECTRICAL MASSETER MUSCLE STIMULATION ALTERS CONDYLAR SHAPE IN ORGAN CULTURE

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AIMS: To examine the effect of electrical stimulation of the masseter muscle on the condylar morphology and the number of chondrocytes under organ culture conditions in which the jaws with the craniomandibular joint were cultured in one block.

MATERIAL AND METHODS: Sixty BALB/c mice of both sexes were divided into three groups. Two groups were

decapitated at the age of 5 days and the cranial base and mandible were dissected out and placed on a culture dish. The masseter muscles of the explants in one group were stimulated with an electric pulsing device delivering an alternating current at a frequency of 0.7 Hz and an amplitude of 5 V with hourly active and silent periods. The explants were fixed after culture periods of 1, 3, 7 and 14 days. The histological sections were examined by a digital image analyser.

RESULTS: In the group that was stimulated electrically, the condylar morphology was extremely flat and gained a mushroom shape where cartilage growth continued in the direction of the flat articular surface. The highest increase in cell count was found in the postero-superior segment of the condyle in the stimulated group.

CONCLUSIONS: The present results indicate that the muscular function in the stimulated groups remodels the morphology of the condyle into a fundamentally altered form which can be seen as a consequence of active growth induced by functionally limited joint movement.

41 THE EXPRESSION OF EMBRYONIC FIBRONECTIN SPLICING VARIANTS IN HUMAN MASSETER MUSCLE

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AIMS: Fibronectin (FN) is an extra-cellular matrix (ECM) protein that is a key constituent of all skeletal muscle matrices. Its deposition increases in a number of pathological conditions, including some muscular dystrophies where a progressive increase in lower face height is often noted. FN is produced in different isoforms due to a process known as alternative splicing, in which a protein module (exon) is either included (spliced variant) or excluded (non-spliced variant). Splicing can occur at three regions within the FN molecule-EIIIA, EIIIB and V. The aim of this study was to investigate the expression of mRNA coding for fibronectin and its spliced variants, EIIIA and EIIIB, in the masseter of patients with vertical facial deformity of developmental origin. **MATERIALS AND METHODS:** Masseter muscle biopsies were taken from 19 patients, 13 long faces (LFS) and 6 normal controls, as confirmed by cephalometric analysis. Five samples of somatic (non-cranial) muscle were also used. Total RNA was extracted from the samples and reverse transcribed to cDNA, prior to amplification by polymerase chain reaction (PCR) using primer pairs specific to the EIIIA or EIIIB regions. The proportion of spliced (where appropriate) to non-spliced message in each sample was determined by densitometric analysis.

RESULTS: Densitometry showed that 15.1 per cent (sd = 11.97; n = 6) of FN mRNA from normal masseter muscle contained the EIIIA exon. This was not significantly different to the level seen in masseter muscle from LFS (15.11 per cent; sd = 13.81; n = 13). These figures were significantly higher ($P < 0.05$) than those seen in the somatic muscle (2.97 per cent; sd = 3.92; n = 5). For all muscle samples

examined, none (0 per cent) of the FN mRNA contained the EIIIB exon.

CONCLUSIONS: Masseter (cranially innervated) from both normal and LFS contains fibronectin mRNA containing the EIIIA exon but not the EIIIB exon (A+B⁻). In contrast, somatic muscle (spinally innervated) contains A+B⁻ fibronectin. These differences in ECM expression may reflect differences in functional demand, embryological origin and innervation of the muscles.

42 BITE FORCE MAGNITUDE AND CRANIOFACIAL MORPHOLOGY

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AIM: To examine the relationship between craniofacial morphology and maximal voluntary bite force.

SUBJECTS: One hundred and twenty-one young adults with (almost) complete dentitions, no functional disorders and no serious malocclusions.

METHODS: Maximal voluntary bite force magnitude and its direction were registered with a 3-D force component transducer. Facial morphology was measured with anthropometrics (transverse dimensions) and cephalometrics. Thirty-seven variables were reduced to nine new variables (principal component analysis). Registration of the bite force direction allowed for construction of bite force moment arm relative to the temporomandibular joint. Bite force moments were assessed and related to the cranio-facial components (stepwise multiple regression.).

RESULTS: Bite force moments related significantly positive with the components describing vertical ($B = 0.3$, $P < 0.01$) and sagittal dimensions ($B = 0.2$, $P < 0.05$), and significantly negative with that describing occlusal inclination ($B = -0.2$, $P < 0.05$). The correlation coefficient R was 0.46. If bite forces were taken instead of moments, the correlation coefficient was 0.37.

CONCLUSION: Magnitude of bite force moments correlated with craniofacial size and occlusal inclination, larger moments were found in individuals with larger and more convergent faces.

43 NASOPHARYNGEAL AND DENTOFACIAL LATERAL CEPHALOMETRIC ANALYSIS IN MOUTH BREATHING PATIENTS

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AIM: To diagnose mouth-breathing patients with nasopharyngeal restriction, prior, if necessary, to referral to an ENT specialist for adenoidectomy.

SUBJECTS AND METHODS: The lateral cephalometric radiographs of 92 patients in two groups were studied. The study group comprised 46 patients (aged 6–15 years) who

were suffering from mouth-breathing. The chief problem was nasopharyngeal obstruction which was clinically diagnosed by an ENT specialist. The control group consisted of 46 patients with normal breathing. Nineteen dentofacial and nasopharyngeal landmarks were used. All radiographs were traced and analysed twice. After determining the dentofacial and nasopharyngeal measurements, a statistical *t*-test was performed to discover which means would demonstrate significant differences. Discriminant analysis was used for significant nasopharyngeal variables.

RESULTS AND CONCLUSIONS: Dentofacial variables: There were six significant differences between the two groups. They were: GoMe-SN; Y-axis; gonial angle; SN-PL; 1 to FH and SNB. The first four variables were higher and the others were lower in the study group. Five nasopharyngeal variables showed significant differences between the two groups: Adenoid-soft palate (McNamara measurement); Adenoid-PMP; Air area; Nasopharyngeal area, and Ba-PMP. The means of these variables were smaller than those of the control group. The discriminant analysis was conducted on all of the above variables as well as age groups (6–10, 11–12, 13–15) and sexes. The discriminant formula with critical point 3.88 and 94.57 per cent correct classification were detected and, as a result, the critical point less than 3.88 revealed the mouth-breathing patients with nasopharyngeal obstruction with 94.54 per cent probability.

44 MOLECULAR SIGNALLING IN THE DEVELOPING CALVARIAL BONES AND SUTURES

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AIMS: To develop an *in vitro* organ culture system which facilitates the study of molecular signalling in the developing calvarial bones and sutures.

MATERIALS: Mouse calvaria aged embryonic day 15. At this stage whilst osteogenesis of the calvaria has commenced, the sutural space is still wide.

METHODS: Calvaria were dissected under a stereomicroscope and placed in a Trowell type organ culture. Explants were observed for 1–4 days, during which time beads impregnated with signalling molecules, known to be involved in calvarial development, were placed at a variety of locations and their effects analysed by *in situ* hybridization.

RESULTS: Explants developed in a manner consistent with suture development *in vivo*. The opposing parietal bone osteogenic fronts approximated but did not fuse. Beads soaked in FGF4 accelerated sutural closure when placed on the osteogenic fronts, but had no such effect when placed on the mid-sutural mesenchyme. BMP4 beads caused an increase in tissue volume both when placed on the osteogenic fronts and on the mid-sutural area, but did not effect suture closure. BMP4 induced the expression of both *Msx1* and *Msx2* genes in sutural tissue, while FGF4 induced only *Msx1*.

It is suggested that the local application of FGF on the osteogenic fronts accelerating suture closure *in vitro*, mimics the pathogenesis of human craniosynostosis syndromes in which mutations in the FGF receptor genes apparently cause constitutive activation of the receptors.

*David Rice is the recipient of the European Orthodontic Society W J B Houston Scholarship.

45 MICROMECHANICAL, NON-INVASIVE INVESTIGATION OF MANDIBULAR AND PHALANGEAL BONE QUALITY DURING GROWTH

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AIMS: To investigate changes in the elastic and micro-mechanical properties of mandibular and phalangeal bone during the developmental period. Structural bone maturity and, indirectly, the mineral density of bone, are important co-factors in orthodontic and dentofacial orthopaedic treatment.

SUBJECTS AND METHODS: The ultrasound transmission velocity (UTV) was determined at the chin and at the middle part of the middle finger of infants and adults. The UTV has been introduced as a non-invasive method to investigate the quality of bone and dental tissues *in vivo* and *in vitro*. The square of velocity of sound transmission through a material (*U*) is directly related to its elastic modulus (*E*) by the following formula: $E = U^2 \rho$ where ρ is the physical density of the material. A commercial measuring instrument, Krautkrämer UDS 10 (Hürth, Germany) with pulsed ultrasound at a frequency of 2 MHz, was used.

One hundred and fifty-six healthy subjects were divided into four groups: (A) infants with an average age of $x = 3.5$ years, (B) children with an average age of 8.9 years, (C) adolescents with an average age of $x = 14.1$ and (D) adults with an average age of 36 years. The data was statistically evaluated using multifactorial ANOVA.

RESULTS: There was no statistical difference in gender, but a significant difference in age in the UTV. The difference between the middle phalanx and the chin was significant. The apparent phalangeal ultrasound transmission velocity measured 1885 ± 174 m/s in infants and 1986 ± 153 m/s in children. In the adolescent group the UTV was 2069 ± 152 m/s, and in the adult group 2169 ± 114 m/s. At the bony chin the UTV was 2069 ± 152 m/s in group A, 1747 ± 120 m/s in group B, 1788 ± 123 m/s in group C, and 1800 ± 105 m/s in group D.

CONCLUSIONS: The quality of bony tissue changes during growth with regard to its elastic and micromechanical properties. These changes are dependent on age but not on gender. The amount of change varies between different bones. The increase in elastic modulus of bone during growth signifies an increase in stiffness and a decrease in mechanical

resistance. With the applied methods an age-dependent assessment for the structural and functional quality of bone can be determined non-invasively and without any side effects.

46 VERTICAL DIMENSION AND PREDICTION OF NASOLABIAL ANGLE

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AIMS: To quantify longitudinal soft tissue profile changes during and following active orthodontic treatment, and to assess the effect of vertical skeletal changes on the soft tissue profile during this period. Cephalometric analyses provide information on the influence of the incisor tooth positions on the soft tissue profile (Holdaway, 1983). Disagreement exists regarding this soft tissue modification (Riedel, 1957; Subtelny, 1961). Moreover, few published studies describe soft tissue changes post-retention (Finnoy *et al.*, 1987).

METHODS: A sample of 83 Class I and Class II males and females (mean post-retention time 11.58 years) was assessed at three time intervals (T1: pre-treatment, T2: post-treatment, and T3: post-retention). A group of normals (Burlington Growth Centre) was matched to the treated groups for comparison. The treated group consisted of four significantly different subgroups (Class I, Class II dento-alveolar, Class II mandibular retrognathism, Class II mandibular rotation). These subjects were matched with respect to their age ranges at T1, T2 and T3. Cephalometric variables describing the craniofacial parameters of these subjects were subjected to descriptive statistics, independent and paired Student's *t*-tests and Pearson product-moment correlation coefficients. Multiple regression equations were used to determine prediction capabilities of the soft versus hard tissues. The significance level was set at $P = 0.001$.

RESULTS: Maxillary incisor retraction occurred in all treated subgroups leading to lip prominence reduction during treatment and this latter change continued following treatment. The nasolabial angle tended to be more obtuse in the treated group which also showed increased hard and soft tissue face heights. Regression analyses showed the relationship with the increase in lower face height.

CONCLUSIONS: Vertical dimension change significantly influences the soft tissue profile. Mandibular rotation was found to be a more useful predictor of nasolabial angle change compared with upper incisor position.

47 STRUCTURE AND FUNCTION OF THE NEUROMUSCULAR SYSTEM

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KEYNOTE ADDRESS

Skeletal muscle fibres are multinucleated cells that arise from fusion of proliferating mononuclear myoblasts. Myonuclei become post-mitotic, but all muscles contain

mononuclear satellite cells which act as reserve-myoblasts and provide new myonuclei during growth and regeneration after injury.

The contractile machinery of muscle fibres consists of actin and myosin filaments which slide past each other during shortening of the fibre; the signal for actin-myosin interaction is the release of Ca^{2+} , from membrane sacs of the sarcoplasmic reticulum into the cytoplasm. This calcium transient is initiated by the action potential of the muscle fibres which is conducted along and into the fibre by means of plasma membrane and T-tubules which link plasma membrane and sarcoplasmic reticulum. The action potential of the muscle fibre starts at the neuromuscular junction after the nerve terminal has released acetylcholine which binds to postsynaptic acetylcholine receptors and thereby opens ion channels. Energy necessary for contraction and excitation-contraction coupling is produced aerobically inside mitochondria and by anaerobic glycolysis in the cytoplasm.

Each motoneuron in the anterior horn of the spinal cord or in motor nuclei of brain nerves innervates 100–1000 muscle fibres and thereby forms a motor unit. Motor units and hence also muscle fibres differ with respect to speed of contraction and fatiguability. The differentiation of the muscle fibres is governed by the motoneuron; all muscle fibres of fast motor units contain a 'fast' myosin isoform and sarcoplasmic reticulum and T-tubules are abundant, and all muscle fibres of a slow motor unit contain a 'slow' myosin isoform. Fatigue-resistant motor units have fibres with many mitochondria ('red' fibres). In most muscles, fast motor units are fatiguable ('fast white' and slow motor units are fatigue-resistant ('slow red')). Extra-ocular, laryngeal and masticatory muscles, however, have also fast motor units that are fatigue-resistant ('fast red'). Furthermore, some animal species produce a masticatory muscle specific fast myosin isoform.

Systemic disorders of the neuromuscular system affect masticatory muscles as well. Examples are motoneuron disease (ALS) which primarily damages motoneurons, myasthenia gravis which is an autoimmune disease blocking acetylcholine receptors, or muscle dystrophies which cause death of individual muscle fibres. Clinically important is malignant hyperthermia, an often fatal disorder which impedes calcium storage by the sarcoplasmic reticulum and during narcosis by means of maintained muscle activity raises the body temperature; spasm of the masseter muscle during induction and intubation may be the first sign.

48 CONSIDERATION OF FUNCTIONAL ASPECTS IN DENTOFACIAL ORTHOPAEDICS AND ORTHODONTICS

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SHELDON FRIEL MEMORIAL LECTURE

The 'jumping the bite' principle of Norman William Kingsley (1829–1913) is one of the first classic examples considering functional aspects in orthodontic therapy.

In 1895 Wilhelm Roux highlighted the importance of function for the development of organs and tissue alteration in his book '*Collected treatises on development mechanics of organisms*'. In 1771, more than a century earlier, Hunter had expressed similar thoughts which could also be found in the works of Farrar in the second half of the 19th Century.

Functional, more physiological therapy, found a strong supporter in Adolf Lorenz (1854–1946), a professor of orthopaedics in Vienna. However, he realized that there was hardly any absolute advantage of certain treatment procedures in comparison with other therapy options. The range of therapeutic procedures in the hands of the therapist has to be multifactorial and balanced. This insight is also of fundamental importance in orthodontics and dentofacial orthopaedics.

Functional aspects already play an important role in the development of the masticatory organs. This was emphasized in four publications entitled 'Functional matrix hypothesis revisited' by M Moss. With regard to the most recent literature, discussions still continue on the primacy problem of genetic or epigenetic influences on growth and development. These days the relative role of genomic and epigenetic mechanisms under functional influences on regulation, control and induction of craniofacial growth and development is stressed. The importance of the interplay of genetic and epigenetic influences can also be realized in adaptive tissue processes by means of the functional matrix hypothesis. This genomic, epigenetic dichotomy is also of crucial importance in orthodontic and orthopaedic tissue alterations in the craniofacial region.

The effects of functional bimaxillary devices will be discussed on the basis of the reports on experimental studies, together with the controversial views and the differences in the clinical application of the appliances.

49 SELECTIVE MASSETER AND TEMPORAL MUSCLE ACTIVATION DEPENDING ON THE MORPHO-FUNCTIONAL SITUATION IN THE OROFACIAL REGION

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AIMS: Previous morphological (e.g. the structural parts of masseter muscle and their innervation, Schumacher, 1961; Kurzmann, 1991) and physiological results (selective control of the motor units of masseter muscle, Stalberg and Eriksson, 1987) demonstrated that there are not only temporal but also spatial aspects of muscle activation in the orofacial region. Thus, a differentiated activation of separate motor regions depending on the localization, the direction and the level of the force input of load applied to the mandible can be supposed. Therefore, the aim of this study was to create a non-invasive electrophysiological technique which characterizes the topography of muscle activation during different functional conditions in the orofacial region.

SUBJECTS AND METHOD: In 44 healthy volunteers, 16-channel surface EMGs were monopolarly recorded from

the temporal and the masseter muscles (reference: contralateral ear lobe) during constant biting on a left and then a right placed force transducer, and during constant frontal as well as lateral force application to the mandible which had to be compensated by the subjects. After power spectral analysis of artefact-free EMG intervals, spectral characteristics (15.6–496 Hz) were evaluated with regard to the time course and the muscle topography (EMG mapping).

RESULTS: Depending on the characteristics of the performed motor tasks, the direction of acting torques, the torque amplitudes etc., the EMG maps of analysed muscle were structured in a specific and reproducible manner. Furthermore, the characteristics of the activation pattern were correlated with the functional situation of the investigated muscles. Thus, there was evidence that the activation patterns were influenced by the changes of the morpho-functional conditions of the orofacial region as occurs in patients with orthodontic problems.

CONCLUSIONS: The results of this study support the previous findings which allowed the assumption for a selective activation of compartments of the masseter and temporal muscles. The detailed analysis of such selective activation patterns caused by biomechanical dysfunctions of the craniomandibular system can be a useful method in diagnostics, follow-up studies, and treatment evaluation of orthodontic patients.

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50 SIGNIFICANCE OF THE VERTICAL DIMENSION IN MAXILLARY SURGERY

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AIM: During orthodontic-surgical treatment a three-dimensional repositioning of the maxilla is required after Le Fort I osteotomy. The pre-operatively planned and desired position of the maxillary segment could often not be realized sufficiently in the surgical procedure. Several authors have described deviations of up to 5 mm in the sagittal and 15 mm in the vertical dimension between the planned and the achieved position. The reason is that the planned position of the maxilla in the sagittal and transverse dimensions is provided by the surgical occlusal splint, but the control of the vertical position was often inadequate. In order to avoid this error the 'model-repositioning instrument' for three-dimensionally controlled cast surgery, and the 'three-dimensional double splint method' for controlled three-dimensional positioning of the maxilla, especially with control in the vertical dimension during surgical procedure, were developed. **SUBJECTS AND METHODS:** A group of 20 adult patients with severe dentofacial deformities were treated according to the Goettingen concept for combined orthodontic-surgical treatment with condylar position control. For cast

surgery the maxillary and mandibular models were mounted in centric relation in an articulator. The maxillary cast was shifted three-dimensionally and controlled to the desired post-operative position using the 'model repositioning instrument'. During the surgical procedure the maxilla was adjusted with special control of the vertical dimension by the 'three-dimensional double splint method' in combination with a surgical facebow. For each patient the positions of three marked reference points on the maxillary dental arch in the pre- and post-operative situation were evaluated using superimposed tracings of the lateral radiographs. These values were compared with the performed movements of the dental maxillary arch during cast surgery.

RESULTS: It can be shown that by use of the new developments the planned position of the maxillary dental arch could be transferred from cast surgery to actual surgery with an accuracy of ± 1 mm sagittally and vertically.

CONCLUSIONS: The application of the Goettingen concept for three-dimensional positioning of the maxilla shows an improvement of accuracy particularly with respect to the vertical dimension and a controlled adjustment of the maxillary dental arch not only during cast surgery, but especially in surgical procedure.

51 EFFECTS OF EXPERIMENTAL SUPRAHYOID MUSCLE MYECTOMY ON RAT MANDIBULAR GROWTH

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AIMS: The possibility of a role played by the suprahyoid muscles in the establishment of a growth direction of the mandible has been suggested (Adamidis and Spyropoulos, 1983). Furthermore, according to the morphogenetic field hypothesis (Spyropoulos and Burdi, 1987), structures that arise from the same morphogenetic field may present reciprocal changes due to environmental and functional demands. In order to test the aforementioned hypothesis the following investigation was planned, based on experimental suprahyoid muscle myectomy.

MATERIALS AND METHOD: Forty-eight four-week-old rats were divided into two experimental and two control groups as follows: A: Twelve animals in which bilateral excision of the anterior digastric muscle was performed. B: Twelve animals in which bilateral excision of the anterior digastric, transverse mandibular and mylohyoid muscles was performed. C: Twelve animals sham operated bilaterally without any muscular excision. D: Twelve control animals not subjected to any operation. The experimental period was 30 days. Lateral and dorsoventral radiographs were taken at day 1 and day 30, following muscular excision. Cephalometric analysis was performed for each animal following an established method and procedure (Tsolakis *et al.*, 1997).

FINDINGS: The absence of the suprahyoid muscles does play a role in the growth direction of the mandible.

Furthermore the absence of the suprahyoid muscles influences, to some extent, the amount of mandibular growth. The above results could be explained by the fact that the suprahyoid muscles are identified as the main protractor muscles for the mandible in rats.

Adamidis I P, Spyropoulos 1983 The effects of lympho-adenoid hypertrophy on the position of the tongue, the mandible and the hyoid bone. *European Journal of Orthodontics* 5: 287–294

Spyropoulos M N, Burdi 1987 Morphogenic fields in craniofacial biology Craniofacial Growth Series, Center for Human Growth and Development, University of Michigan, Ann Arbor

Tsolakis A I, Spyropoulos M N, Katsavrias E, Alexandridis K 1997 Effects of altered mandibular function on mandibular growth after condylectomy. *European Journal of Orthodontics* 19: 9–19

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52 LIMITATIONS IN THE TREATMENT OF LONG AND SHORT FACES

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KEYNOTE ADDRESS

The vertical development of the face is dominated by functional factors that are frequently difficult to change. This applies particularly to patients with an excessive vertical lower anterior face height. It is assumed that the development of the face is primarily determined by interaction of internal and external functional components. The factors involved in this interaction will be explained and differences in response to treatment will be demonstrated. In addition, the influence of growth after completion of treatment and the way this can affect the changes realized will be shown.

Recommendations will be made regarding diagnosis, treatment planning and clinical procedures, including retention protocols for patients with excessive long and short lower anterior face heights. Different aspects involved will be illustrated by treatment results 25 years out of retention.

53 PRINCIPLES AND CEPHALOMETRIC ASSESSMENT OF FUNCTIONAL MAGNETIC CORRECTION

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AIM: The breakthrough in using permanent magnets in dentistry came with the introduction of new rare earth magnetic alloys (SmCo_5 , $\text{Sm}_2\text{Co}_{17}$). Thus, for the same magnitude of force a 20 times smaller magnetic unit can be applied. This miniaturizing effect made the use of magnets in the oral cavity feasible. The unique characteristics of magnetic forces include: high force to volume ratio, force is proportional to the inverse square of the distance ($F=1/d^2$), 3D orientation of attractive magnetic forces, no interruption of magnetic force lines by intermittent media, no friction and no fatigue. These characteristics justify the application of magnets in specific orthodontic malocclusions such as intrusion of teeth, alignment of impacted teeth and functional correction. The objectives of the present study were to examine a newly designed functional magnetic system (FMS) to correct Class II malocclusions and to evaluate the treatment results.

SUBJECTS AND METHODS: Twenty-five Class II patients were treated with a FMS appliance. Lateral radiographs were taken before and after one year of treatment. Pancherz's analysis was applied to assess treatment results.

RESULTS: All 25 patients demonstrated correction of the malocclusion although some of them did not reach a full Class I canine relationship. Six target zones of Class II correction were defined. These included: distalization of maxillary dental arch, mesialization of mandibular dental arch, constraining anterior maxillary growth, accelerating mandibular anterior growth, accelerating disto-vertical maxillary alveolar process growth and accelerating mesio-vertical mandibular alveolar process growth. The contribution of each of the six parameters differed from subject to subject even when patients demonstrated a similar initial malocclusion and final dental correction.

CONCLUSIONS: The FMS proved to be a reliable functional appliance with a high performance record. No universal pattern of functional correction was found. That is, if in one patient the component of mandibular skeletal effect contributed 70 per cent to the functional correction, in the next patient its contribution was 40 per cent or less (but never dropped to zero), while distalization of maxillary dental arch and constraining anterior maxillary growth (headgear effect) were the major contributors to functional correction.

54 SERIAL EXTRACTIONS VERSUS PREMOLAR EXTRACTIONS IN THE PERMANENT DENTITION

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AIMS: Comparison of duration and outcome of orthodontic treatment in two groups of patients with marked crowding: Serial extraction started in the early mixed dentition (Group I); extractions postponed until the permanent dentition (Group II).

SUBJECTS AND METHODS: The registrations were made on plaster models and cephalograms of 20 patients in each of the two groups before (T1) and after treatment (T2). The mean ages at T1 were 8.2 years (SD 1.2 years) in Group

I and 11.6 years (SD 1.9 years) in Group II. Occlusal parameters were assessed according to a modified PAR Index, and relevant angular cephalometric variables were evaluated. Overall observation and treatment time (T2-T1), the duration of active therapy, the duration of fixed appliance therapy (as one part of active therapy), as well as the number of appointments, were registered.

RESULTS: At T1, inter-group differences as regards PAR score, as well as the cephalometric findings, were statistically insignificant. In the Group I the PAR-score improved on average from 28 to 2.7, and in Group II from 24.1 to 4.8. These inter-group differences and changes were statistically significant ($P < 0.05$). Overall observation and treatment time (T2-T1) was longer in Group I (6 versus 3.6 years; $P < 0.001$), whereas fixed appliances were used for a markedly shorter period (1.4 versus 2.3 years; $P < 0.001$). The average number of appointments in Group I was 43.9 (SD 11.4) and in Group II 35.9 (SD 11.2); $P < 0.01$.

CONCLUSIONS: In the serial extraction group a higher reduction in PAR score was registered in spite of a more pronounced anterior crowding at T1, and a markedly shorter period with fixed appliances. However, the overall duration of treatment and the number of appointments were significantly higher.

55 A NUCLEAR MAGNETIC RESONANCE STUDY OF TEMPOROMANDIBULAR JOINT CHANGES FOLLOWING FUNCTIONAL ORTHOPAEDIC TREATMENT USING THE 'WÜRZBURG APPROACH'

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AIM: Insufficient efficacy of bimaxillary appliance wear in the treatment of a skeletal Angle Class II division 1 malocclusions resulted in the introduction of the extra-oral anterior traction to fix the bimaxillary device to the maxilla. In combination with up-and-down elastics, it maintains the mandible in a therapeutic position (construction bite position) during sleep. Thus, this combination prevents the drop-out from bimaxillary appliance wear during the night and guarantees the adaptation of the muscles and articular structures.

METHOD: As part of a major prospective multi-group study, treatment progress was compared using lateral cephalograms (ANB angle) and study casts (overjet, occlusion) obtained at the beginning and end of active treatment. Nuclear magnetic resonance (NMR) tomograms of the joints were taken to examine the condylar and disc position following bite correction.

The study sample comprised 30 patients with Angle Class II or Class II division 1 malocclusions with a distal occlusion exceeding $\frac{1}{2}$ premolar width; the age at the onset of treatment averaged 11.6 ± 0.5 years. A splint (bite plane) was used for deprogramming the occlusion for 2 weeks to monitor the stability of the corrected position of the mandible. Twenty subjects matched for age and type of malocclusion who were

treated without extra-oral traction and up-and-down elastics served as the control.

FINDINGS: The extent of bite correction achieved in the study group treated with extra-oral traction and up-and-down elastics was significantly superior ($P = 0.04$) to that achieved in the control group. The NMR images obtained after bite correction show that the articular disc and the condyle were located in their physiological position. Thus, the intended remodelling and adaptation of the articular structures was confirmed.

56 QUANTITATIVE ASSESSMENT OF THE HEALING OF AUTOGENOUS BONE GRAFTS

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AIMS: To quantitatively assess the amount of new bone formed by intramembranous and endochondral autogenous bone grafts.

MATERIALS AND METHODS: Eighteen critical sized defects were created on the parietal bone of nine New Zealand white rabbits (two defects per rabbit). In the experimental group (five rabbits), each rabbit was grafted with intramembranous bone in one defect and with endochondral bone in the other. In the control group (four rabbits), one defect in each rabbit was left empty (passive control) and the other was grafted with rabbit skin collagen (active control). After 14 days, the rabbits were killed and the defects were prepared for histological analysis. Serial sections were made across the whole defect. Each defect was divided into five regions spaced 1500 μm apart. Two sections were randomly drawn from each region. Quantitative analysis was performed on 100 sections using an image analyser computer software system (Videoplan) to assess the amount of new bone formed in each defect.

RESULTS: One hundred and sixty-six per cent more new bone was formed in defects grafted with intramembranous bone than those grafted with endochondral bone. No bone was formed in either active or passive controls. This represented an extremely significant difference ($P < 0.0001$, unpaired t -test) between the two groups.

CONCLUSIONS: Intramembranous autogenous bone grafts produce more bone than endochondral grafts in the skull. Clinically, it is recommended that bone grafts of intramembranous origin are used to replace lost membranous bone in the oral cavity, as well as skull defects, whenever possible.

57 THE AETIOLOGY OF EXTREME VERTICAL DIMENSIONS

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KEYNOTE ADDRESS

The term 'vertical dimension' usually refers to malocclusions characterized by excessive lower anterior face height.

However, the term must also include a consideration of the other vertical dimension which includes those characterized by a short lower anterior face height.

This presentation will address the multiple aetiological factors which underline both types of malocclusion symptoms. The ease or difficulty with which the aetiological factor or factors specific to an individual malocclusion can be modified may influence the difficulty of treatment and the long-term stability of such treatment. It is, therefore, imperative that the clinician is able to differentially identify the aetiological factors which underlie a particular malocclusion. In addition, whether or not a particular aetiological factor operates to produce a malocclusion will depend upon the individual reaction to the particular neuromuscular stimulus which is generated by the aetiological factor.

This presentation will review the known aetiological factors for malocclusion characterized by excessive lower face height and overclosure. It will also discuss the neuromuscular changes necessary for a malocclusion to ensue.

58 VERTICAL DIMENSIONS IN CLEFT LIP AND PALATE PATIENTS: CEPHALOMETRIC, ACOUSTIC RHINOMETRIC AND MORPHOMETRIC DATA

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AIMS: The factors determining vertical dimensions in the growth of cleft lip and palate (CLP) patients are still an open issue. It was, therefore, the objective of this study to investigate the relationship between vertical development and parameters such as nasal airway configuration, palatal vault and other morphometric values.

METHODS: A consecutive sample of 19 adult patients with complete unilateral CLP, aged 19–31 years, who had not undergone corrective skeletal osteotomies, were included in the study. Nasal volume recorded by acoustic rhinometry, was compared with morphometric parameters such as palatal vault and Sergl's Apical-Base-Relation-Index, as well as to lateral cephalographs with special regard to parameters indicating vertical and sagittal skeletal development. Statistical analysis was performed using the non-parametric rank-correlation coefficient (Spearman).

RESULTS: Spearman's rank correlation coefficient revealed a close correlation of the cleft-sided nasal volume and valve area with the distances Pt-Spp ($P < 0.01$) and N-Spa ($P < 0.05$), the palatal vault ($P < 0.05$), and apical base of the upper jaw ($P < 0.01$) respectively.

CONCLUSION: The morphological correlation of cleft palate associated nasal airway disturbances can be described as a cleft-sided stenosis of the nasal valve and a deficit of cleft-sided nasal volume. A close correlation of the degree of these structural anomalies and morphological parameters of midface growth was confirmed. The results support the hypothesis that midface development is at least co-influenced by nasal airway impairment.