Accuracy and precision of manual segmentation of the maxillary sinus in MR images—a method study

To assess the accuracy and precision of segmentation of the maxillary sinus in MR images to evaluate the potential usefulness of this modality in longitudinal studies of sinus development. A total of 15 healthy subjects who had been both craniofacial CT and MR scanned were included and the 30 maxillary sinus volumes were evaluated using segmentation. Two of the authors did segmentation of MRI and one of these authors did double segmentation. Agreement in results between CT and MRI as well as inter- and intraexaminer errors were evaluated by statistical and three-dimensional analysis. The intraclass correlation coefficient for volume measurements for both method error, inter- and intraexaminer agreement were > 0.9 [maximal 95% confidence interval of 0.989-0.997, p <0.001] and the limit of agreement for all parameters were 0.9 = excellent agreement] and border distance [95% percentile Hausdorff Distance (HD) <2 mm = acceptable agreement]. The results were replicable and not influenced by systematic errors. We found a high accuracy and precision of manual segmentation of the maxillary sinus in MR images. The largest mean errors were found close to the orbit and the teeth. Advances in knowledge: MRI can be used for 3D models of the paranasal sinuses with equally good results as CT and allows longitudinal follow-up of sinus development.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Rigshospitalet, Technical University of Denmark
Publication date: 2018
Peer-reviewed: Yes

Publication information
Journal: British Journal of Radiology
Volume: 91
Issue number: 1085
Article number: 20170663
ISSN (Print): 0007-1285
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.92 SJR 0.729 SNIP 0.918
Web of Science (2017): Impact factor 1.814
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.61 SJR 0.686 SNIP 0.884
Web of Science (2016): Impact factor 2.05
Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.2 SJR 0.891 SNIP 1.259
Web of Science (2015): Impact factor 1.84
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.07 SJR 0.855 SNIP 1.2
Web of Science (2014): Impact factor 2.026
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.71 SJR 0.678 SNIP 0.973
Computed tomography (CT) images have been used in very few studies on distances to the ethmoidal arteries in the orbit. Most other studies have included direct measurements on cadavers and frequently quote the 24-12-6 mm rule to describe distances from the anterior lacrimal crest to the anterior and posterior ethmoidal foramina (AEF and PEF), optic canal (OC), respectively. However, the large interindividual variation of distances renders absolute values less applicable in a clinical setting. Preoperative measurements on CT images may provide more precise distances than absolute rules and thus lead to safer orbital surgery. The authors hypothesize that the distances to the ethmoidal arteries and the length of the medial wall are positively correlated and that measurements of the distances from the posterior lacrimal crest (PLC) on CT images are feasible with a low intra-and interobserver variability. Fifty intact orbits from 25 Caucasian cadavers were exenterated and examined. In additional, high-resolution CT scans of 48 orbits from 24 other Caucasian nonexenterated cadavers were examined. Distances were measured from 4 different anterior landmarks to the AEF and PEF and the OC. Distances from the most anterior landmarks to the arteries were positively correlated with the length of the medial wall. Measurements of the distances from the PLC to the ethmoidal arteries on CT images were feasible with a low intra-and interobserver variability. In conclusion, iatrogenic damage to the ethmoidal arteries in the orbit may be best avoided by using CT measurements in presurgical planning.

An Applied Anatomical Study of the Ethmoidal Arteries: Computed Tomographic and Direct Measurements in Human Cadavers: Computed Tomographic and Direct Measurements in Human Cadavers

Computed tomography (CT) images have been used in very few studies on distances to the ethmoidal arteries in the orbit. Most other studies have included direct measurements on cadavers and frequently quote the 24-12-6 mm rule to describe distances from the anterior lacrimal crest to the anterior and posterior ethmoidal foramina (AEF and PEF), optic canal (OC), respectively. However, the large interindividual variation of distances renders absolute values less applicable in a clinical setting. Preoperative measurements on CT images may provide more precise distances than absolute rules and thus lead to safer orbital surgery. The authors hypothesize that the distances to the ethmoidal arteries and the length of the medial wall are positively correlated and that measurements of the distances from the posterior lacrimal crest (PLC) on CT images are feasible with a low intra-and interobserver variability. Fifty intact orbits from 25 Caucasian cadavers were exenterated and examined. In additional, high-resolution CT scans of 48 orbits from 24 other Caucasian nonexenterated cadavers were examined. Distances were measured from 4 different anterior landmarks to the AEF and PEF and the OC. Distances from the most anterior landmarks to the arteries were positively correlated with the length of the medial wall. Measurements of the distances from the PLC to the ethmoidal arteries on CT images were feasible with a low intra-and interobserver variability. In conclusion, iatrogenic damage to the ethmoidal arteries in the orbit may be best avoided by using CT measurements in presurgical planning.
A study of familial Char syndrome involving the TFAP2B gene with a focus on facial shape characteristics

In this case study, we investigate a child presenting with patent ductus arteriosus, short philtrum, duck-bill lips, strabismus, a flat nasal bridge, a broad forehead, low-set ears, hypertelorism, up-slanting palpebral fissures, almond-shaped eyes, and hypodontia, all leading to the clinical diagnosis of Char syndrome. Genetic analysis showed heterozygosity for the novel variant c.851T>C, p. Leu284Ser in the TFAP2B gene. Family analysis suggested that at least 20 members, extending six generations back, were affected. All 10 members available for genetic testing were heterozygous for the novel pathogenic variant. Qualitative analysis of the facial dysmorphology in the proband and three of the affected family members using three-dimensional surface scanning showed that the major deviations were observed in the forehead/eyebrow, nose, upper lip, and chin regions with, for example, a flattened nose and reduced height of the upper lip and the face. Furthermore, it is suggested that Char syndrome is associated with disturbances of tooth formation and eruption. Copyright (c) 2018 Wolters Kluwer Health, Inc. All rights reserved.
Early post-natal development of the mandibular permanent first molar in infants with unilateral complete cleft lip and palate

Objectives: Studies have shown that the mandibular permanent first molar (M1(Inf)) in young children with isolated cleft palate is characterized by delay in maturation and has reduced crown width. Consequently, it is of interest to investigate the early maturation and width of the follicle and crown of M1(Inf) in children with combined cleft lip and palate.

Design: Retrospective, longitudinal study. Cephalometric X-rays of 47 consecutive Danish children with UCCLP (37 males;
10 females) and 44 with unilateral incomplete cleft lip (UICL) (29 males; 15 females) examined at 2 and 22 months of age. UICL served as control group. Maturation (according to Haavikko), width of follicle (FW) and crown (CW) of M1(inf) were assessed.

Results: The maturation of the first mandibular molar was delayed in both genders at 2 and 22 months of age. FW and CW were smaller in children with UCLC at both 2 and 22 months of age. There was a positive correlation between maturation and FW. Conclusions: Maturation of the first mandibular molar is delayed in both genders, and FW and CW were reduced in UCLC compared to controls. Maturation was correlated with FW.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, University of Copenhagen
Contributors: Hermann, N. V., Darvann, T. A., Kreiborg, S.
Pages: 196-201
Publication date: 2017
Peer-reviewed: Yes

Publication information
Journal: Orthodontics & Craniofacial Research
Volume: 20
Issue number: 4
ISSN (Print): 1601-6335
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.2 SJR 1.318 SNIP 1.549
Web of Science (2017): Impact factor 2.077
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.4 SJR 0.965 SNIP 0.974
Web of Science (2016): Impact factor 1.115
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.55 SJR 0.886 SNIP 1.321
Web of Science (2015): Impact factor 1.64
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.65 SJR 1.242 SNIP 1.295
Web of Science (2014): Impact factor 1.061
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.01 SJR 1.309 SNIP 1.48
Web of Science (2013): Impact factor 1.288
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.08 SJR 1.253 SNIP 1.527
Web of Science (2012): Impact factor 1.186
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.77 SJR 0.716 SNIP 0.946
Web of Science (2011): Impact factor 1.652
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.989 SNIP 1.413
Web of Science (2010): Impact factor 1.809
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.631 SNIP 1.027
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 1.137 SNIP 1.209
Automatic measurement of orbital volume in unilateral coronal synostosis

Premature fusion of the coronal suture on one side of the calvaria (unilateral coronal synostosis, UCS) results in asymmetric craniofacial development and the deformation of the orbits. Often this necessitates surgery, where CT scanning is employed to obtain measures of the bony orbit. These measures are typically computed by guided procedures that require expert time. We propose a method with higher degree of automation based on finding an optimal smooth closed surface. CT scans of 17 infants with UCS are included in our experimental validation, where we compare our method to expert guided segmentations. We obtain similar measures, as well as high Dice scores, compared to the experts. The run time for the proposed approach with a prototype implementation is around 3 minutes on a standard laptop, making the method suitable for rapid evaluation of orbital volume in UCS.
conventional lateral cephalograms and 2-dimensional photographs.

**General information**

State: Published
Organisations: Department of Applied Mathematics and Computer Science, University of Copenhagen, Chang Gung University
Number of pages: 10
Pages: 182-191
Publication date: 2016
Peer-reviewed: Yes

**Publication information**

Journal: American Journal of Orthodontics and Dentofacial Orthopedics
Volume: 149
Issue number: 2
ISSN (Print): 0889-5406
Ratings:

- BFI (2018): BFI-level 1
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 1
- Scopus rating (2017): CiteScore 1.2 SJR 1.289 SNIP 1.595
- Web of Science (2017): Impact factor 1.842
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 1
- Scopus rating (2016): CiteScore 1.24 SJR 1.265 SNIP 1.537
- Web of Science (2016): Impact factor 1.472
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 1.33 SJR 1.317 SNIP 1.595
- Web of Science (2015): Impact factor 1.69
- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 1.47 SJR 1.234 SNIP 1.619
- Web of Science (2014): Impact factor 1.382
- BFI (2013): BFI-level 2
- Scopus rating (2013): CiteScore 1.53 SJR 1.713 SNIP 1.707
- Web of Science (2013): Impact factor 1.437
- BFI (2012): BFI-level 2
- Scopus rating (2012): CiteScore 1.45 SJR 1.471 SNIP 1.449
- Web of Science (2012): Impact factor 1.458
- BFI (2011): BFI-level 2
- Scopus rating (2011): CiteScore 1.43 SJR 1.247 SNIP 1.566
- Web of Science (2011): Impact factor 1.381
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 1.254 SNIP 1.416
- Web of Science (2010): Impact factor 1.354
- BFI (2009): BFI-level 2
- Scopus rating (2009): SJR 1.189 SNIP 1.476
- BFI (2008): BFI-level 2
- Scopus rating (2008): SJR 1.056 SNIP 1.274
- Scopus rating (2007): SJR 0.831 SNIP 1.275
- Scopus rating (2006): SJR 0.895 SNIP 1.435
- Scopus rating (2005): SJR 0.714 SNIP 1.459
- Scopus rating (2004): SJR 0.779 SNIP 1.382
- Scopus rating (2003): SJR 0.642 SNIP 1.372
- Scopus rating (2002): SJR 0.696 SNIP 0.728
- Scopus rating (2001): SJR 0.637 SNIP 0.477
Short mandible - a possible risk factor for cleft palate with/without a cleft lip

Structured Abstract Objectives To estimate the influence of a short mandible on the risk of developing a cleft palate with/without a cleft lip (CP). Setting and sample population The retrospective sample consisted of 115 2-month-old Danish infants with CP, and 70 control infants with unilateral incomplete cleft lip (UICL). Material and Methods Cephalometric X-rays were obtained. Mandibular length (L-m) was measured and corrected for body length (L-b) to remove influence of varying body length in the sample. Logistic regression was applied to the corrected mandibular length (L-mc) to calculate the risk of having a cleft palate. Results The mean mandibular length in the group with CP was about 4mm shorter than in the control group. Odds ratio (OR) was calculated to be 0.58 (95% confidence interval 0.48-0.68), implying that an individual's risk of cleft palate with/without a cleft lip increases about 50% per mm decrease in mandibular length. Conclusions A special facial type including a short mandible is a possible risk factor for cleft palate, and it was found that the risk of cleft palate increases 58% per mm decreases in mandibular length.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Statistics and Data Analysis, University of Copenhagen
Contributors: Hermann, N. V., Darvann, T. A., Ersbøll, B. K., Kreiborg, S.
Pages: 106-114
Publication date: 2014
Peer-reviewed: Yes

Publication information
Journal: Orthodontics & Craniofacial Research
Volume: 17
Issue number: 2
ISSN (Print): 1601-6335
Ratings:
BFI (2018): BFI-level 2
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.2 SJR 1.318 SNIP 1.549
Web of Science (2017): Impact factor 2.077
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.4 SJR 0.965 SNIP 0.974
Web of Science (2016): Impact factor 1.115
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 1.55 SJR 0.886 SNIP 1.321
Web of Science (2015): Impact factor 1.64
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 1.65 SJR 1.242 SNIP 1.295
Web of Science (2014): Impact factor 1.061
Web of Science (2014): Indexed yes
Modeling of Craniofacial Anatomy, Variation, and Growth

The topic of this thesis is automatic analysis of craniofacial images with respect to changes due to growth and surgery, inter-subject variation and intracranial volume estimation. The methods proposed contribute to the knowledge about specific craniofacial anomalies, as well as provide a tool for detailed analyses for clinical and research purposes.

Most of the applications in this thesis rely on non-rigid image registration by the means of warping one image into the coordinate system of another image. This warping results in a deformation field that describes the anatomical correspondence between the two images. To elaborate further: a computational atlas of the average anatomy was constructed. Using non-rigid registration, image data from a subject is automatically transformed into the coordinate space of the atlas. In this process, all knowledge built into the atlas is transferred to the subject, thus creating a personalized atlas. The knowledge built into the atlas is e.g. location of anatomical regions and landmarks of importance to surgery planning and evaluation or population studies. With these correspondences, various analyses could be carried out e.g. quantification of growth, inter-subject variation etc. Besides image registration, a volumetric segmentation method using graph cuts was developed and applied for intracranial volume estimation. Graph cut is a fast method for segmentation utilizing a suitable graph.

Three different craniofacial anomalies were examined in this thesis: Cleft lip and palate, unicoronal synostosis, and Crouzon syndrome. Using the proposed methods, highly detailed variation was assessed for cleft lip and palate, correspondence between images obtained before and after lip repair was established for cleft lip and palate, the intracranial volume was estimated for infants with unicoronal synostosis, and nally, craniofacial growth patterns were quantified for Crouzon syndrome in a mouse model.
Early postnatal development of the mandibular permanent first molar in infants with isolated cleft palate

Background. Based on measurements on dental casts, smaller permanent teeth in children with cleft palate have previously been reported in the literature; however, the early maturation of teeth and the size of the follicles and crowns have not been investigated. Hypothesis. The maturation of the mandibular permanent first molar (M1inf) is delayed, and the mesiodistal diameters of the follicle and crown of M1inf, respectively, are reduced in children with isolated cleft palate (ICP). Design. Retrospective, longitudinal. Cephalometric X-rays were available for 2 and 22 months old children with clefts (64 children with ICP, and a control group of 38 children with unilateral incomplete cleft lip). The width of the follicle and the crown of M1inf, and the maturation of M1inf were assessed. Intra-observer error was acceptable. Results. M1inf maturation was delayed in children with ICP at both 2 and 22 months of age. The mesiodistal diameter of the crown of M1inf in the ICP group was reduced. Thus, the two hypotheses could not be refuted. Conclusions. Children with ICP showed smaller dimensions of the M1inf, and in addition, the maturation of M1inf was delayed.
Micro-CT analyses of apical enlargement and molar root canal complexity
Markvart M, Darvann TA, Larsen P, Dalstra M, Kreiborg S, Bjørndal L. Micro-CT analyses of apical enlargement and molar root canal complexity. International Endodontic Journal, 45, 273–281, 2012. Aim To compare the effectiveness of two rotary hybrid instrumentation techniques with focus on apical enlargement in molar teeth and to quantify and visualize spatial details of instrumentation efficacy in root canals of different complexity. Methodology Maxillary and mandibular molar teeth were scanned using X-ray microcomputed tomography. Root canals were prepared using either a GT/Profile protocol or a RaCe/NiTi protocol. Variables used for evaluation were the following: distance between root canal surfaces before and after preparation (distance after preparation, DAP), percentage of root canal area remaining unprepared and increase in canal volume after preparation. Root canals were classified according to size and complexity, and consequences of unprepared portions of narrow root canals and intraradicular connections/isthmuses were included in the analyses. One- and two-way anova were used in the statistical analyses. Results No difference was found between the two techniques: DAPapical-third (P = 0.590), area unpreparedapical-third (P = 0.126) and volume increaseapical-third (P = 0.821). Unprepared root canal area became larger in relation to root canal size and complexity, irrespective of the technique used. Percentage of root canal area remaining unprepared was significantly lower in small root canals and complex systems compared to large root canals. The isthmus area per se contributed with a mean of 17.6%, and with a mean of 25.7%, when a narrow root canal remained unprepared. Conclusions The addition of isthmuses did not significantly alter the ratio of instrumented to unprepared areas at total root canal level. Distal and palatal root canals had the highest level of unprepared area irrespective of the two instrumentation techniques examined.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Aarhus University, Technical University of Denmark, University of Copenhagen
Contributors: Markvart, M., Darvann, T. A., Larsen, P., Dalstra, M., Kreiborg, S., Bjørndal, L.
Pages: 273-281
Publication date: 2012
Peer-reviewed: Yes
Three-dimensional analysis of the pulp cavity on surface models of molar teeth, using X-ray micro-computed tomography im. The purpose of this study was to investigate the scanning and segmentation precision of surface models of molars for the detection of small volumes, such as the reduced pulp cavity; formation of mineral deposits; detection of narrow root canals and to improve the clinical and morphological understanding of the number of root canals and their configuration.

Methods. Eighteen human molars were scanned using X-ray micro-computed tomography. The reconstruction of the surface models had a precision of <1 voxel, using three-dimensional software and quantitative color mapping. In order to relate the measurements to changes over time the size of the pulp chambers was classified in two well-defined groups.

Results. The mineral deposits were more evenly distributed in small pulp chambers than in large, but complete root canal calcification was never observed. No difference was observed in the material with respect to the presence of intra-radicular connections. In upper molars, a second mesiobuccal canal (mb2) frequency of 91% was found. The difference in length between the first mesiobuccal canal (mb1) and mb2 was <1 mm. The number of root canals could be related to the number of root cones.

Conclusion. In summary, three-dimensional surface models were made with a high precision; an increased accumulation of mineral deposits was noted in molars with small pulp chambers and combined with the consistent pattern of intra-radicular connections, the potential endodontic treatment complexity is underlined in such cases. Finally, an improved understanding of root canal prevalence was reached, when merging well-defined definitions on root morphology and clinical classification systems.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Aarhus University, Copenhagen University Hospital, University of Copenhagen
Contributors: Markvart, M., Bjørndal, L., Darvann, T. A., Larsen, P., Dalstra, M., Kreiborg, S.
Pages: 133-139
Publication date: 2012
Peer-reviewed: Yes

Publication information
Journal: Acta Odontologica Scandinavica
Volume: 70
Issue number: 2
ISSN (Print): 0001-6357
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 1.62 SJR 0.706 SNIP 0.997
Web of Science (2017): Impact factor 1.522
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 1.44 SJR 0.724 SNIP 1.011
Web of Science (2016): Impact factor 1.232
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 1.14 SJR 0.643 SNIP 0.991
Web of Science (2015): Impact factor 1.171
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.14 SJR 0.611 SNIP 0.736
Web of Science (2014): Impact factor 1.03
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 1.3 SJR 0.72 SNIP 1.073
Web of Science (2013): Impact factor 1.309
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.56 SJR 0.685 SNIP 1.148
Web of Science (2012): Impact factor 1.358
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
Objectives. To investigate and compare facial asymmetry in subjects with JIA with unilateral, bilateral or no TM joint (TMJ) involvement.

Methods. Eighty-one subjects with JIA: 22 with unilateral TMJ involvement (Group 1), 15 with bilateral TMJ involvement (Group 2) and 44 with no TMJ involvement (Group 3). Panoramic X-rays and three-dimensional (3D) photographs (surface scans) were obtained for all subjects. Panoramic X-rays were rated for severity of TMJ involvement. For each individual, a spatially detailed facial asymmetry map was created from the 3D photograph. Mean and variability of asymmetry were calculated for each of the three groups and compared.

Results. Distinct patterns of asymmetry were found in Groups 1 and 2. With mean asymmetry values up to 3.5 mm, Group 1 exhibited a significantly greater amount of asymmetry in a broad band along the lower jaw extending from the region of the condyle to the chin than Group 2. The mean facial asymmetry (1 s.d.) for each JIA group was 2.3 (0.9), 2.0 (0.7), 1.7 (0.5) mm for Groups 1, 2 and 3, respectively.

Conclusion. JIA subjects with TMJ involvement displayed patterns of facial asymmetry consistent with the destruction of the condylar growth centre, leading to mandibular asymmetry with displacement of the bony chin. Facial asymmetry quantification was found to be an effective method for assessing both the amount and the localization and spatial extent of asymmetry in all 3Ds.

General information
State: Published
Organizations: Department of Informatics and Mathematical Modeling, Embedded Systems Engineering, Copenhagen University Hospital, University of Copenhagen
Pages: 586-592
Publication date: 2011
Peer-reviewed: Yes

Publication information
Journal: Rheumatology
Volume: 50
Issue number: 3
ISSN (Print): 1462-0324
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Helmet Versus Active Repositioning for Plagiocephaly: A Three-Dimensional Analysis

BACKGROUND AND PURPOSE: Orthotic helmets and active repositioning are the most common treatments for deformational plagiocephaly (DP). Existing evidence is not sufficient to objectively inform decisions between these options. A three-dimensional (3D), whole-head asymmetry analysis was used to rigorously compare outcomes of these 2 treatment methods.

PATIENTS AND METHODS: Whole-head 3D surface scans of 70 infants with DP were captured before and
after treatment by using stereophotogrammetric imaging technology. Helmeted (n = 35) and nonhelmeted/actively repositioned (n = 35) infants were matched for severity of initial deformity. Surfaces were spatially registered to a symmetric template, which was deformed to achieve detailed right-to-left point correspondence for every point on the head surface. A ratio-metric asymmetry value was calculated for each point relative to its contralateral counterpart. Maximum and mean asymmetry values were determined. Change in mean and maximum asymmetry with treatment was the basis for group comparison. RESULTS: The helmeted group had a larger reduction than the repositioned group in both maximum (4.0% vs 2.5%; P = .02) and mean asymmetry (0.9% vs 0.5%; P = .02). The greatest difference was localized to the occipital region. CONCLUSIONS: Whole-head 3D asymmetry analysis is capable of rigorously quantifying the relative efficacy of the 2 common treatments of DP. Orthotic helmets provide statistically superior improvement in head symmetry compared with active repositioning immediately after therapy. Additional studies are needed to (1) establish the clinical significance of these quantitative differences in outcome, (2) define what constitutes pathologic head asymmetry, and (3) determine whether superiority of orthotic treatment lasts as the child matures. Pediatrics 2010;126:e936-e945

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Pages: E936-E945
Publication date: 2010
Peer-reviewed: Yes

**Publication information**

Journal: Pediatrics
Volume: 126
Issue number: 4
ISSN (Print): 0031-4005
Ratings:
- BFI (2018): BFI-level 2
- Web of Science (2018): Indexed yes
- BFI (2017): BFI-level 2
- Scopus rating (2017): CiteScore 5.15 SJR 3.337 SNIP 2.662
- Web of Science (2017): Impact factor 5.515
- Web of Science (2017): Indexed yes
- BFI (2016): BFI-level 2
- Scopus rating (2016): CiteScore 5.16 SJR 3.511 SNIP 2.725
- Web of Science (2016): Impact factor 5.705
- BFI (2015): BFI-level 2
- Scopus rating (2015): CiteScore 5.07 SJR 3.379 SNIP 2.855
- Web of Science (2015): Impact factor 5.196
- BFI (2014): BFI-level 2
- Scopus rating (2014): CiteScore 4.97 SJR 3.546 SNIP 2.976
- Web of Science (2014): Impact factor 5.473
- BFI (2013): BFI-level 2
- Scopus rating (2013): CiteScore 5.23 SJR 3.287 SNIP 3.016
- Web of Science (2013): Impact factor 5.297
- ISI indexed (2013): ISI indexed yes
- BFI (2012): BFI-level 2
- Scopus rating (2012): CiteScore 5.23 SJR 3.153 SNIP 3.036
- Web of Science (2012): Impact factor 5.119
- ISI indexed (2012): ISI indexed yes
- BFI (2011): BFI-level 2
- Scopus rating (2011): CiteScore 5 SJR 3.258 SNIP 3.042
- Web of Science (2011): Impact factor 5.437
- ISI indexed (2011): ISI indexed yes
- BFI (2010): BFI-level 2
- Scopus rating (2010): SJR 3.047 SNIP 2.734
- Web of Science (2010): Impact factor 5.391
- Web of Science (2010): Indexed yes
Mandibular dimensions and growth in 11- to 26-week-old Danish fetuses studied by 3D ultrasound

Objective To present normative data on prenatal mandibular morphology and growth. Material and Methods Fifty-four normal fetuses (Danish Caucasian) were included in the study (gestational age: 11-26 weeks). Fetuses were scanned using a GE Voluson 730 Expert 3D scanner. Scans were visualized and analyzed using GE 4DVIEW (TM) software. Mandibular dimensions [base length (B), ramus height (H), and total length (L)] and the mandibular angle (phi) were measured, and the mandibular index was calculated. Method error was estimated by duplicate measurements. Growth was calculated by regressing measured variables on age. Results Mandibular measurements were found to be reliable [precision: 0.5-1.2 mm (ISD)]. Mean mandibular variable values at week 11: B = 5.2 +/- 2.5 mm; H = 2.7 +/- 1.3 mm; L = 7.7 +/- 3.2 mm; phi = 149 +/- 6.0 degrees; and at week 26: B = 22.6 +/- 2.5 mm; H = 12.3 +/- 1.3 mm; L = 33.1 +/- 3.2 mm; phi = 135 +/- 6.0 degrees. A linear model described growth (B-g/H-g/L-g/phi(g)) giving B-g = 1.2; H-g = 0.64; L = 1.7 mm/week; phi(g) = -0.9 degrees/week. Conclusion Normative 3D data values for the human mandible in 11- to 26-week-old fetuses were presented. All measured mandibular parameters could be described using a linear increasing model from 11 to 26 weeks. All linear dimensions increased in size, while the mandibular angle decreased steadily during the observation period.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Pages: 408-412
Publication date: 2010
Peer-reviewed: Yes

Publication information
Journal: Prenatal Diagnosis
Volume: 30
Issue number: 5
ISSN (Print): 0197-3851
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.24 SJR 1.139 SNIP 0.989
Web of Science (2017): Impact factor 2.779
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.62 SJR 1.329 SNIP 1.085
Web of Science (2016): Impact factor 2.523
Multivariate Analysis of Variance: Finding significant growth in mice with craniofacial dysmorphology caused by the Crouzon mutation

Crouzon syndrome is characterized by growth disturbances caused by premature fusion of the cranial growth zones. A mouse model with mutation Fgfr2C342Y, equivalent to the most common Crouzon syndrome mutation (henceforth called the Crouzon mouse model), has a phenotype showing many parallels to the human counterpart. Quantifying growth in the Crouzon mouse model could test hypotheses of the relationship between craniosynostosis and dysmorphology, leading to better understanding of the causes of Crouzon syndrome as well as providing knowledge relevant for surgery planning. In the present study we used micro-CT scans of 4-week-old mice (N=5) and 6-week-old mice (N=10) with Crouzon syndrome (Fgfr2 C342Y/+) were compared to control groups of 4-week-old wild-type mice (N=5) and 6-week-old wild-type mice (N=10), respectively.

General information
Prenatal 3D Ultrasound Diagnostics In Cleidocranial Dysplasia

A 34-year-old Caucasian woman with cleidocranial dysplasia (CCD) and a known family history of CCD was referred for an ultrasound examination in the first trimester of her second pregnancy. Molecular genetic analysis of the RUNX2 gene was non-informative. A routine 2D ultrasound examination carried out at a local hospital at gestational age 12 weeks showed no signs of CCD. A 3D ultrasound examination in week 15+4 showed a fetus with typical CCD features including large fontanelles, lack of nasal bones, clavicles without the typical S-form, as well as severe delay in calvarial ossification, especially in the midline. Serial 3D ultrasound examinations during pregnancy confirmed the diagnosis, and over time the manifestations became even more distinct. The diagnosis was clinically confirmed at birth. This case suggests that the typical craniofacial CCD traits, including wide un-mineralized areas in the calvarial midline and missing nasal bones, are easily recognizable using 3D ultrasound as early as in week 15. Copyright © 2009 S. Karger AG, Basel.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Pages: 36-39
Publication date: 2009
Peer-reviewed: Yes

Publication information
Journal: Fetal Diagnosis and Therapy
Volume: 25
Issue number: 1
ISSN (Print): 1015-3837
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.14 SJR 1.183 SNIP 1.099
Web of Science (2017): Impact factor 1.813
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 2.46 SJR 1.677 SNIP 1.331
Web of Science (2016): Impact factor 2.699
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2.71 SJR 1.986 SNIP 1.327
Web of Science (2015): Impact factor 2.7
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 2.4 SJR 1.413 SNIP 1.207
Web of Science (2014): Impact factor 2.939
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.04 SJR 1.4 SNIP 1.158
Web of Science (2013): Impact factor 2.295
ISI indexed (2013): ISI indexed yes
The purpose of this work was to assess the technical performance of a three-dimensional surface imaging system for geometric accuracy and maximum field of view. The system was designed for stereophotogrammetry capture of digital images from three-dimensional surfaces of the head, face, and neck. A mannequin head was prepared for imaging by adding texture in the form of red paint, and facial landmarks as black ink dots. The mannequin was imaged at the manufacturer’s recommended settings for human studies. Colour-coded surface difference images among repeated exposures were computed. We compared measurements of physical linear distance with digital measurements. The three-dimensional stereophotogrammetry system had a mean error in the three-dimensional surfaces of 0.057 mm, a repeatability error (variance) of 0.0016 mm, a mean error of 0.6 mm in linear measurements compared with manual measurements, and a field of view of 170 degrees horizontally and 102 degrees vertically.
A Method for Evaluating Treatment in Infants with Deformational Plagiocephaly

Deformational Plagiocephaly (DP) is a term describing head asymmetry and deformation commonly seen in infants. DP affects the back of the head and, to a lesser extent, the forehead. The deformity is thought to result from protracted...
external pressure to the skull in one position. Treatment is non-surgical and involves parental education on infant repositioning to avoid pressure on the attended side, and, in many cases, orthotic molding helmet therapy. The purpose of this work was to develop a method for assessment of helmet therapy employing a statistical analysis of change in head asymmetry. The clinical population consisted of 37 infants for whom 3D surface scans of the head had been obtained both before and after their helmet treatment. Detailed point correspondence between all head surfaces was established by tps-transforming a symmetric template to each of the head surfaces. This also ensured full left-right point correspondence. Asymmetry was quantified by the ratio of distances between sides, measured from a midpoint between the ears to corresponding surface points on opposite sides of the midsagittal plane. The method was able to quantify and localize the asymmetry, which occurred predominantly in the back and/or the front of the head. Change in asymmetry was determined by computing the difference between measurement before and after the therapy. The results revealed that the head asymmetry was, in most cases, corrected in the posterior and/or anterior regions. The values of asymmetry change were statistically analyzed using Principal Components Analysis. The model localized the two major improvements to the posterior and anterior regions of the head, respectively, where also the main head asymmetries had been detected (and clinically observed). Results deem this method suitable for treatment evaluation. In addition, results establish helmet therapy as an effective treatment for improving head asymmetry in infants with DP.

A Point-Wise Quantification of Asymmetry Using Deformation Fields: Application to the Study of the Crouzon Mouse Model

This paper introduces a novel approach to quantify asymmetry in each point of a surface. The measure is based on analysing displacement vectors resulting from nonrigid image registration. A symmetric atlas, generated from control subjects is registered to a given subject image. A comparison of the resulting displacement vectors on the left and right side of the symmetry plane, gives a point-wise measure of asymmetry. The asymmetry measure was applied to the study of Crouzon syndrome using Micro CT scans of genetically modified mice. Crouzon syndrome is characterised by the premature fusion of cranial sutures, which gives rise to a highly asymmetric growth. Quantification and localisation of this asymmetry is of high value with respect to surgery planning and treatment evaluation. Using the proposed method, asymmetry was calculated in each point of the surface of Crouzon mice and wild-type mice (controls). Asymmetry appeared in similar regions for the two groups but the Crouzon mice were found significantly more asymmetric. The localisation ability of the method was in good agreement with ratings from a clinical expert. Validating the quantification ability is a less trivial task due to the lack of a gold standard. Nevertheless, a comparison with a different, but less accurate measure of asymmetry revealed good correlation.
A Statistical Model of Head Asymmetry in Infants with Deformational Plagiocephaly

Deformational plagiocephaly is a term describing cranial asymmetry and deformation commonly seen in infants. The purpose of this work was to develop a methodology for assessment and modelling of head asymmetry. The clinical population consisted of 38 infants for whom 3-dimensional surface scans of the head had been obtained both before and after their helmet orthotic treatment. Non-rigid registration of a symmetric template to each of the scans provided detailed point correspondence between scans. A new asymmetry measure was defined and was used in order to quantify and localize the asymmetry of each infant's head, and again employed to estimate the improvement of asymmetry after the helmet therapy. A statistical model of head asymmetry was developed (PCA). The main modes of variation were in good agreement with clinical observations, and the model provided an excellent and instructive quantitative description of the asymmetry present in the dataset.

Automatic Detection of Wild-type Mouse Cranial Sutures

In the study of craniofacial malformations, the cranial sutures are often of interest. The premature fusion of sutures occurring in e.g. Crouzon and Apert syndrome can lead to asymmetric head shape, enlarged intracranial pressure and blindness. In large population studies of such syndromes, automatic detection of the cranial sutures becomes important. We have previously built a craniofacial, wild-type mouse atlas from a set of 10 Micro CT scans using a B-spline-based nonrigid registration method by Rueckert et al. Subsequently, all volumes were registered nonrigidly to the atlas. Using these transformations, any annotation on the atlas can automatically be transformed back to all cases. For this study, two rounds of tracing seven of the cranial sutures, were performed on the atlas by one observer. The average of the two rounds was automatically propagated to all the cases. For validation, the observer traced the sutures on each of the mouse volumes as well. The observer outperforms the automatic approach by approximately 0.1 mm. All mice have similar errors while the suture error plots reveal that suture 1 and 2 are cumbersome, both for the observer and the automatic approach. These sutures can be hard to detect with the eye. We still believe that overall, the errors are not considerable and by qualitatively estimating the accuracy, the automatic sutures are very close to the observer sutures. Our plan is to improve the results by local feature detection methods.

Computational mouse atlases and their application to automatic assessment of craniofacial dysmorphology caused by the Crouzon mutation Fgfr2

Crouzon syndrome is characterised by premature fusion of sutures and synchondroses. Recently the first mouse model of the syndrome was generated, having the mutation Cys342Tyr in Fgfr2c, equivalent to the most common human Crouzon/Pfeiffer syndrome mutation. In this study, a set of Micro CT scannings of the skulls of wild-type mice and Crouzon mice were analysed with respect to the dysmorphology caused by Crouzon syndrome. A computational craniofacial atlas was built automatically from the set of wild-type mouse Micro CT volumes using (i) affine and (ii) nonrigid image registration. Subsequently, the atlas was deformed to match each subject from the two groups of mice. The accuracy of
these registrations was measured by a comparison of manually placed landmarks from two different observers and automatically assessed landmarks. Both of the automatic approaches were within the inter-observer accuracy for normal specimens, and the nonrigid approach was within the inter-observer accuracy for the Crouzon specimens. Four linear measurements, skull length, height and width and inter-orbital distance, were carried out automatically using the two different approaches. Both automatic approaches assessed the skull length, width and height accurately for both groups of mice. The nonrigid approach measured the inter-orbital distance accurately for both groups while the affine approach failed to assess this parameter for both groups. Using the full capability of the nonrigid approach, local displacements obtained when registering the nonrigid wild-type atlas to a nonrigid Crouzon mouse atlas were determined on the surface of the wild-type atlas. This revealed a 0.6 mm bending in the nasal region and a 0.8 mm shortening of the zygoma, which are similar to characteristics previously reported in humans. The most striking finding of this analysis was an angulation of approximately 0.6 mm of the cranial base, which has not been reported in humans. Comparing the two different methodologies, it is concluded that the nonrigid approach is the best way to automatically assess linear skull parameters. Furthermore, the nonrigid approach is essential when it comes to analysing local, nonlinear shape differences.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Embedded Systems Engineering
Pages: 37-52
Publication date: 2007
Peer-reviewed: Yes

**Publication Information**

Journal: Journal of Anatomy
Volume: 211
Issue number: 1
ISSN (Print): 0021-8782
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 2
Scopus rating (2017): CiteScore 2.46 SJR 1.078 SNIP 1.102
Web of Science (2017): Impact factor 2.479
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 2
Scopus rating (2016): CiteScore 2.18 SJR 1.046 SNIP 1.035
Web of Science (2016): Impact factor 2.182
BFI (2015): BFI-level 2
Scopus rating (2015): CiteScore 2.32 SJR 1.061 SNIP 1.138
Web of Science (2015): Impact factor 2.154
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 2
Scopus rating (2014): CiteScore 2.14 SJR 0.992 SNIP 1.22
Web of Science (2014): Impact factor 2.097
BFI (2013): BFI-level 2
Scopus rating (2013): CiteScore 2.56 SJR 1.183 SNIP 1.094
Web of Science (2013): Impact factor 2.227
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 2
Scopus rating (2012): CiteScore 2.64 SJR 1.111 SNIP 1.209
Web of Science (2012): Impact factor 2.357
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 2
Scopus rating (2011): CiteScore 2.44 SJR 1.185 SNIP 1.177
Web of Science (2011): Impact factor 2.37
ISI indexed (2011): ISI indexed yes
BFI (2010): BFI-level 1
Craniofacial Statistical Deformation Models of Wild-type mice and Crouzon mice

Crouzon syndrome is characterised by the premature fusion of cranial sutures and synchondroses leading to craniofacial growth disturbances. The gene causing the syndrome was discovered approximately a decade ago and recently the first mouse model of the syndrome was generated. In this study, a set of Micro CT scannings of the heads of wild-type (normal) mice and Crouzon mice were investigated. Statistical deformation models were built to assess the anatomical differences between the groups, as well as the within-group anatomical variation. Following the approach by Rueckert et al. we built an atlas using B-spline-based nonrigid registration and subsequently, the atlas was nonrigidly registered to the cases being modelled. The parameters of these registrations were then used as input to a PCA. Using different sets of registration parameters, different models were constructed to describe (i) the difference between the two groups in anatomical variation and (ii) the within-group variation. These models confirmed many known traits in the wild-type and Crouzon mouse craniofacial anatomy. Moreover, they showed new traits, not reported before.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Publication date: 2007

Host publication information
Title of host publication: International Symposium on Medical Imaging 2007, San Diego, CA
Source: orbit
Source-ID: 200306
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Estimation of independent non-linear deformation modes for analysis of craniofacial malformations in crouzon mouse

Crouzon syndrome is a genetic disease resulting in premature fusion of cranial sutures and synchondroses causing craniosynostosis. A decade ago the Crouzon gene was discovered, and recently the first mouse model of the syndrome was generated. In this study, a set of Micro CT scannings of the heads of wild-type (normal) mice and Crouzon mice were investigated. We present for what we believe is the first time, a statistical deformation model based on independent component analysis (ICA). A set of deformation parameters for each mouse was calculated using a B-spline-based nonrigid registration. From the parameters controlling the deformations for each subject, the statistical model was estimated. ICA is demonstrated to provide localized deformation components, many of which give a clear separation between Crouzon and wild-type mice. This is a clear improvement of a previous principal component-based model, which
only provided one global deformation component describing the disease. The ICA components allow interpretation of each deformation feature to be carried out independently of other features, and provides a basis for linking the observed craniofacial malformations to the fusing of sutures. ICA revealed an interesting new finding, not previously reported in the literature, namely asymmetries in the head in Crouzon mice. This phenomenon is probably caused by asymmetric closure of craniofacial sutures.

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Publication date: 2007

Host publication information
Title of host publication: 2007 IEEE International Symposium on Biomedical Imaging
Publisher: IEEE
Keywords: image registration, independent component analysis, Statistical deformation model, atlas
Electronic versions:
Hansen2.pdf
DOIs:
10.1109/ISBI.2007.357097

Bibliographical note
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Source: orbit
Source-ID: 200112
Research output: Research - peer-review › Article in proceedings – Annual report year: 2007

Palatal Surface Area of Maxillary Plaster Casts: A Comparison Between Two-Dimensional and Three-Dimensional Measurements
Objective: To investigate the relationship between corresponding two-dimensional and three-dimensional measurements on maxillary plaster casts taken from photographs and three-dimensional surface scans, respectively.

Materials and Methods: Corresponding two-dimensional and three-dimensional measurements of selected linear distances, curve lengths, and (surface) areas were carried out on maxillary plaster casts from individuals with unilateral or bilateral cleft lip and palate. The relationship between two-dimensional and three-dimensional measurements was investigated using linear regression.

Results and Conclusions: Error sources in the measurement of three-dimensional palatal segment surface area from a two-dimensional photograph were identified as photographic distortion (2.7%), interobserver error (3.3%), variability in the orientation of the plaster cast (3.2%), and natural shape variation (4.6%). The total error of determining the cleft area/palate surface area ratio was 15%. In population studies, the effect of using two-dimensional measurements is a decrease of discriminating power. In well-calibrated setups, a two-dimensional measurement of the cleft area/palate surface area ratio may be converted to a three-dimensional measurement by use of a multiplication factor of 0.75.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Contributors: Darvann, T. A., Hermann, N. V., Erbsbøll, B. K., Kreiborg, S., Berkowitz, S.
Pages: 381-390
Publication date: 2007
Peer-reviewed: Yes

Publication information
Journal: Cleft Palate - Craniofacial Journal
Volume: 44
Issue number: 4
ISSN (Print): 1055-6656
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
Sparse Statistical Deformation Model for the Analysis of Craniofacial Malformations in the Crouzon Mouse

Crouzon syndrome is characterised by the premature fusion of cranial sutures. Recently the first genetic Crouzon mouse model was generated. In this study, Micro CT skull scannings of wild-type mice and Crouzon mice were investigated.
Using nonrigid registration, a wild-type mouse atlas was built. The atlas was registered to all mice providing parameters controlling the deformations for each subject. Our previous PCA-based statistical deformation model on these parameters revealed only one discriminating mode of variation. Aiming at distributing the discriminating variation over more modes we built a different model using Independent Component Analysis (ICA). Here, we focus on a third method, sparse PCA (SPCA), which aims at approximating the properties of a standard PCA while introducing sparse modes of variation. This approach is compared to a standard PCA and ICA. The results show that the SPCA outperforms both ICA and PCA with respect to the Fisher discriminant.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Publication date: 2007

**Host publication information**

Title of host publication: Scandinavian Conference on Image Analysis 2007
Publisher: Springer
Keywords: Sparse PCA, statistical deformation model, Crouzon syndrome
Source: orbit
Source-ID: 200307
Research output: Research - peer-review > Article in proceedings – Annual report year: 2007

**Automatic Assessment of Global Craniofacial Differences between Crouzon mice and Wild-type mice in terms of the Cephalic Index**

This paper presents the automatic assessment of differences between Wild-Type mice and Crouzon mice based on high-resolution 3D Micro CT data. One factor used for the diagnosis of Crouzon syndrome in humans is the cephalic index, which is the skull width/length ratio. This index has traditionally been computed by time-consuming manual measurements that prevent large-scale populational studies. In this study, an automatic method to estimate cephalic index for this mouse model of Crouzon syndrome is presented. The method is based on constructing a craniofacial atlas of Wild-type mice and then registering each mouse to the atlas using affine transformations. The skull length and width are then measured on the atlas and propagated to all subjects to obtain automatic measurements of the cephalic index. The registration accuracy was estimated by RMS landmark errors. Even though the accuracy of landmark matching is limited using only affine transformations, the errors were considered acceptable. The automatic estimation of the cephalic index was in full agreement with the gold standard measurements. Discriminant analysis of the three scaling parameters resulted in a good classification of the mouse groups.

**General information**

State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling, Embedded Systems Engineering
Pages: 49-57
Publication date: 2006

**Host publication information**

Title of host publication: MICCAI 2006 workshop: Craniofacial Image Analysis for Biology, Clinical Genetics, Diagnostics and Treatment
Electronic versions: imm4885.pdf
Source: orbit
Source-ID: 200309
Research output: Research - peer-review > Article in proceedings – Annual report year: 2006

**Early postnatal development of the mandible in children with isolated cleft palate and children with nonsyndromic Robin sequence**

Objective: Analysis of early postnatal mandibular size and growth velocity in children with untreated isolated cleft palate (ICP), nonsyndromic Robin sequence (RS), and a control group of children with unilateral incomplete cleft lip (UICL).

Material: 114 children (66 isolated cleft palate, 7 Robin sequence, 41 unilateral incomplete cleft lip) drawn from a group representing all Danish cleft children born from 1976 through 1981. All children were examined at both 2 and 22 months of age. Methods: Cephalometric x-rays and maxillary plaster casts. Mandibular length and height were measured and mandibular growth velocity (mm/year) was calculated. Cleft width was measured on the casts at 2 months of age. Results: Mean mandibular length and posterior height were significantly smaller in isolated cleft palate and Robin sequence, compared with unilateral incomplete cleft lip. Mandibular length in Robin sequence was also significantly shorter,
compared with isolated cleft palate. No significant difference was found between mean mandibular growth velocities in the three groups. No significant correlation was found between mandibular length and cleft width in either isolated cleft palate or Robin sequence at 2 months of age. Conclusion: The children with isolated cleft palate and Robin sequence had small mandibles shortly after birth, but with a relatively normal growth potential. No true mandibular catch-up growth was found up to 22 months of age in either group. No significant correlation was found between mandibular size and cleft width in either group at 2 months of age. However, there was a significant trend toward the shorter the mandible, the more severe the sagittal extension of the cleft.
Quantitative ultrasound tissue characterization in shoulder and thigh muscles – a new approach

Background: The echogenicity patterns of ultrasound scans contain information of tissue composition in muscles. The aim was: (1) to develop a quantitative ultrasound image analysis to characterize tissue composition in terms of intensity and structure of the ultrasound images, and (2) to use the method for characterization of ultrasound images of the supraspinatus muscle, and the vastus lateralis muscle. Methods: Computerized texture analyses employing first-order and higher-order grey-scale statistics were developed to objectively characterize ultrasound images of the supraspinatus muscle, and the vastus lateralis muscle. Results: The mean grey-scale intensity was higher in the vastus lateralis muscle (p < 0.05) than in the supraspinatus muscle (average value of middle measuring site 51.4 compared to 35.0). Furthermore, the number of spatially connected and homogeneous regions (blobs) was higher in the vastus lateralis (p < 0.05) than in the supraspinatus (average for m. vastus lateralis: 0.092 mm(-2) and for m. supraspinatus: 0.016 mm(-2)). Conclusion: The higher intensity and the higher number of blobs in the vastus lateralis muscle indicates that the thigh muscle contained more non-contractile components than the supraspinatus muscle, and that the muscle was coarser. The image analyses supplemented each other and gave a more complete description of the tissue composition in the muscle than the mean grey-scale value alone.
Sagittal synostosis: II. Cranial morphology and growth after the modified pi-plasty

The aim of this study was to characterise the postoperative cranial growth and morphology after a modified pi-plasty for sagittal synostosis. The shape of the skull of 82 patients with isolated premature synostosis of the sagittal suture (SS group) operated on with a modified pi-plasty was studied longitudinally. Forty-five children with unilateral incomplete cleft lip (UICL), evaluated longitudinally at the ages of 2.4 and 23.2 months were used as controls. A standardised radiocephalometric technique was used for image acquisition. The radiocephalograms were analysed using a modification of a method developed by Kreiborg, which included the digitisation of 89 landmarks of the calvaria, cranial base, and orbit (43 in the lateral and 46 in the frontal projections), the production of mean shape plots for each group, and the intergroup comparison of a series of 78 variables (linear distance between selected landmarks, and angles defined by groups of three landmarks). Paired and unpaired t tests were used to assess the differences between the variables studied. These were accepted as significant for values of $p$.
Sagittal synostosis: I. Preoperative morphology of the skull

The aim of this study was to characterise the preoperative morphology of the skull in sagittal synostosis in an objective and quantified way. The shapes of the skulls of 105 patients with isolated premature synostosis of the sagittal suture (SS group) were studied and compared with those of a control group of 72 children with unilateral incomplete cleft lip (UICL). A standardised radiocephalometric technique was used to obtain the images. A modification of a method developed by Kreiborg was used to analyse the radiocephalograms, which included the digitisation of 88 landmarks in the calvaria, skull base, and orbit (42 in the lateral and 46 in the frontal projections), the production of plots of mean shape for each group, and the intergroup comparison of a series of 81 variables (linear distance between selected landmarks, and angles defined by groups of three landmarks). Data from a subgroup of 66 patients aged 5 to 8 months were further compared to age-matched normative data in terms of seven angular and linear calvarial, cranial base and orbital variables. In a comparative analysis of the mean lateral plots, the foreheads of the study group (SS) had a more pronounced anterior slope and were also more convex. The vertex area was located more anteriorly, and was less convex. The occipital curvature was more prominent. Analysis of the mean frontal plots revealed a lack in convexity and lateral projection of the upper parietal regions, as well as a lower location of the line of maximum skull width. Comparison of the mean values of an SS subgroup to age-matched normative data showed a longer (p <0.001) and narrower skull (p <0.001) and a greater interorbital distance (p <0.001). The cranial base angle, the sella to nasion, and sella to basion lengths did not differ significantly. Sagittal synostosis is characterised by an extensive deformity of the cranial vault, with an essentially normal cranial base. The widened interorbital distance is probably related to compensatory metopic hyperactivity.

Towards Describing Crouzon syndrome via a Craniofacial Atlas

General information
State: Published
Organisations: Image Analysis and Computer Graphics, Department of Informatics and Mathematical Modeling
Research output: Research - peer-review; Journal article – Annual report year: 2006
Three-dimensional analysis of mandibular growth and tooth eruption

Normal and abnormal jaw growth and tooth eruption are topics of great importance for several dental and medical disciplines. Thus far, clinical studies on these topics have used two-dimensional (2D) radiographic techniques. The purpose of the present study was to analyse normal mandibular growth and tooth eruption in three dimensions based on computer tomography (CT) scans, extending the principles of mandibular growth analysis proposed by Bjork in 1969 from two to three dimensions. As longitudinal CT data from normal children are not available (for ethical reasons), CT data from children with Apert syndrome were employed, because it has been shown that the mandible in Apert syndrome is unaffected by the malformation, and these children often have several craniofacial CT scans performed during childhood for planning of cranial and midface surgery and for follow-up after surgery. A total of 49 datasets from ten children with Apert syndrome were available for study. The number of datasets from each individual ranged from three to seven. The first CT scan in each of the ten series was carried out before 1 year of age, and the ages for the 49 scans ranged from 1 week to 14.5 years. The mandible and the teeth were segmented and iso-surfaces generated. Landmarks were placed on the surface of the mandible, along the mandibular canals, the inner contour of the cortical plate at the lower border of the symphysis menti, and on the teeth. Superimposition of the mandibles in the longitudinal series was performed using the symphysis menti and the mandibular canals as suggested by Bjork. The study supported the findings of stability of the symphysis menti and the mandibular canals as seen in profile view previously reported by Bjork & Skieller in 1983. However, the mandibular canals were, actually, relocated laterally during growth. Furthermore, the position of tooth buds remained relatively stable inside the jaw until root formation started. Eruption paths of canines and premolars were vertical, whereas molars erupted in a lingual direction. The 3D method would seem to offer new insight into jaw growth and tooth eruption, but further studies are needed.
Early Craniofacial Morphology and Growth in Children With Bilateral Complete Cleft Lip and Palate

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Pages: 424-438
Publication date: 2004
Peer-reviewed: Yes

Publication information
Journal: Cleft Palate Craniofacial Journal
Volume: 41
Issue number: 4
ISSN (Print): 1055-6656
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 1.1 SJR 0.757 SNIP 0.938
Methods for Measurement and Analysis of Craniofacial Morphology and Growth in Children with Cleft Lip and Palate

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Contributors: Darvann, T. A., Ersbøll, B. K.
Publication date: 2004
Active Shape Analysis of Mandibular Growth
This work contains a clinical validation using biological landmarks of a Geometry Constrained Diffusion registration of mandibular surfaces. Canonical Correlations Analysis is extended to analyse 3D landmarks and the correlations are used as similarity measures for landmark clustering. A novel Active Shape Model is proposed targeting growth modelling by applying Partial Least Squares regression in decomposing the Procrustes tangent space. Shape centroid size is applied as dependent variable but the method generalizes to handle other, both uni- and multivariate, effects probing for high covariation wrt. shape variation.

General Information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Publication date: 2003

Host publication Information
Title of host publication: Medical Image Computing and Computer-Assisted Intervention - MICCAI
Publisher: Springer
Source: orbit
Source-ID: 58530
Research output: Research - peer-review › Article in proceedings – Annual report year: 2003

Craniofacial Morphology and Growth Comparisons In Children With Robin Sequence, Isolated Cleft Palate, and Unilateral Complete Cleft Lip and Palate
Objective: Comparison of early craniofacial morphology and growth in children with nonsyndromic Robin Sequence (RS), isolated cleft palate (ICP), and unilateral complete cleft lip and palate (UCCLP).

Subjects: One hundred eight children with cleft: 7 with RS, 53 with ICP, and 48 with UCCLP were included in the study. The children were drawn from the group of all Danish children with cleft born 1976 through 1981.

Method: Three-projection infant cephalometry.

Results: The craniofacial morphology in the RS, ICP, and UCCLP groups had some common characteristics: a wide maxilla with decreased length and posterior height, wide nasal cavity, short mandible, bimaxillary retrognathia, and reduced pharyngeal airway. The shortest mandible was found in RS followed by ICP and UCCLP; the pharyngeal airway was reduced in RS and ICP; compared with UCCLP; and the maxillary complex and nasal cavity were wider in UCCLP than in the other groups. The amount of facial growth in all three groups was similar; however, the direction was more vertical in UCCLP than in RS and ICP.

Conclusion: Except for a shorter RS mandible, the facial morphology of infants with RS and ICP was similar, as was the amount of facial growth and the growth pattern. The differences in facial morphology can be ascribed to the difference in the primary anomaly. The amount of facial growth was similar in the three groups; however, the growth pattern showed a more vertical direction in UCCLP than in RS and ICP. It is hypothesized that the mandibular retrognathia in RS represents the outer end of that of the ICP distribution.

General Information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Pages: 373-396
Publication date: 2003
Peer-reviewed: Yes

Publication information
Early Craniofacial Morphology and Growth in Children With Nonsyndromic Robin Sequence

Purpose: Craniofacial morphology and growth comparisons in children with untreated nonsyndromic Robin Sequence (RS) and a control group with unilateral incomplete cleft lip (UICL) in which the lip was surgically closed at 2 months of age.

Material: The 52 children (7 RS and 45 UICL) included in the study were drawn from a group representing all Danish cleft children born 1976 through 1981. The ages of the children were 2 and 22 months at the time of examination 1 and 2, respectively.

Method: The method of investigation was three-projection cephalometry. Craniofacial morphology was analyzed by means of linear, angular, and area variables. Growth at a specific anatomical location in a patient was defined as the displacement vector from the coordinate of the corresponding landmark at examination 1 to its coordinate at examination 2.

Results: The most striking findings in the RS group were markedly increased posterior maxillary width, increased width of the nasal cavity, short maxilla with reduced posterior height, short mandible, bimaxillary retrognathia, and severe reduction in size of the pharyngeal airway. The amount of facial growth was similar in the two groups; however, a tendency toward a more vertical growth direction was observed in the RS group.

Conclusion: Facial morphology in children with RS differed significantly from that of children with UICL at both 2 and 22 months of age. The magnitude of facial growth was similar in the two groups, whereas a tendency toward a more vertical facial growth direction was observed in the RS group.
3D techniques in studies of craniofacial anomalies

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Computer Science and Engineering
Pages: 273-279
Publication date: 2000

Host publication information
Title of host publication: Oral and Maxillofacial Radiology Today
Place of publication: Amsterdam, Holland
Publisher: Elsevier Science B.V.
Editor: Fuchihata, H.
URLs:
Source: orbit
Source-ID: 200643
Research output: Research - peer-review › Book chapter – Annual report year: 2000
Automated Image Analysis in Undetermined Sections of Human Permanent Third Molars

A computerized histomorphometric analysis was made of Karnovsky-fixed, hydroxethylmethacrylate embedded and toluidine blue/pyronin-stained sections to determine: (1) the two-dimensional size of the coronal odontoblasts given by their cytoplasm:nucleus ratio; (2) the ratio between the number of coronal odontoblasts and dentinal tubules; and (3) the relation between odontoblast size and adjacent predentine. All conditions were measured in relation to three well-defined sectioning profiles of the dentinal tubules. The sections were randomly taken from 10 unerupted and erupted third-molar crowns. Sixty-three photomicrographs (x100), equally distributed among the three sectioning profiles, were scanned in a high-resolution scanner to produce images for the analysis. After initial user interaction for the description of training classes on one image, an automatic segmentation of the images with respect to odontoblast cell nuclei, cytoplasm and background was computed by statistical discriminant analysis. In longitudinal profiles of the dentinal tubules the cytoplasm:nucleus ratio in erupted teeth was 3.1 ± 0.54, and the mean of the odontoblast cell:dentinal tubule ratio was 1.19 ± 0.20. Analysis of cytoplasm:nucleus ratio and the adjacent predentine in relation to the chosen sectioning profiles disclosed that there was less variation in the predentine measurements in the longitudinal sections. Thus, in future two-dimensional studies of the odontoblast-predentine region only longitudinal sectioning profiles should be analysed. The use of advanced image processing on undemineralized tooth sections provides a rational foundation for further work on the reactions of the odontoblasts to external injuries including dental caries.

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling, Image Analysis and Computer Graphics
Pages: 329-332
Publication date: 1997
Peer-reviewed: Yes

Publication information
Journal: Archives of Oral Biology
Volume: 42
Issue number: 4
ISSN (Print): 0003-9969
Ratings:
BFI (2018): BFI-level 1
Web of Science (2018): Indexed yes
BFI (2017): BFI-level 1
Scopus rating (2017): CiteScore 2.17 SJR 0.752 SNIP 0.958
Web of Science (2017): Impact factor 2.05
Web of Science (2017): Indexed yes
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 1.93 SJR 0.735 SNIP 0.881
Web of Science (2016): Impact factor 1.748
BFI (2015): BFI-level 1
Scopus rating (2015): CiteScore 2 SJR 0.809 SNIP 0.91
Web of Science (2015): Impact factor 1.733
BFI (2014): BFI-level 1
Scopus rating (2014): CiteScore 1.99 SJR 0.768 SNIP 1.021
Web of Science (2014): Impact factor 1.735
BFI (2013): BFI-level 1
Scopus rating (2013): CiteScore 2.07 SJR 0.795 SNIP 1.016
Web of Science (2013): Impact factor 1.88
ISI indexed (2013): ISI indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): CiteScore 1.78 SJR 0.598 SNIP 0.929
Web of Science (2012): Impact factor 1.549
ISI indexed (2012): ISI indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): CiteScore 1.85 SJR 0.626 SNIP 1.008
Web of Science (2011): Impact factor 1.603
ISI indexed (2011): ISI indexed yes
3-D analysis of tooth formation and eruption in patients with craniofacial anomalies
A number of craniofacial anomalies or syndromes involve severe disturbances of tooth formation and eruption (e.g. Apert syndrome, Crouzon syndrome, tricho-dento-osseous syndrome, cleidocranial dysplasia, and cleft lip and palate). So far, studies of these dental problems have been limited to two-dimensional analysis from orthopantomograms, intra-oral X-rays or cephalometric radiographs. A method for visualization of the developing tooth crowns in three dimensions based on CT-scans of the jaws has been developed (Bro-Nielsen et al., 1996). The purpose of the present study was to apply this new visualization method to the analysis of the complex dental problems found in some of the syndromes listed above.

General information
State: Published
Organisations: Computer Science and Engineering, Department of Informatics and Mathematical Modeling
Pages: 763-765
Publication date: 1996

Host publication information
Title of host publication: Medical Informatics Europe '96: Human Facets in Information Technologies
Publisher: IOS Press
Keywords: medical image processing, data visualisation, computerised tomography
Source: orbit
Source-ID: 200188
Research output: Research - peer-review › Article in proceedings – Annual report year: 1996

3D analysis of tooth formation and eruption in patients with craniofacial anomalies

General information
State: Published
Organisations: Department of Informatics and Mathematical Modeling
Contributors: Bro-Nielsen, M., Kreiborg, S., Larsen, P., Darvann, T. A.
Pages: 763-765
Publication date: 1996

Host publication information
Title of host publication: Proc. Medical Informatics Europe
Place of publication: Amsterdam
Publisher: IOS Press
Projects:

**Statistical Shape Modelling of the Human Cochlear with Application to Cochlear Implant Surgical Procedures**
Kjer, H. M., PhD Student, Department of Informatics and Mathematical Modeling
Paulsen, R. R., Main Supervisor, Department of Informatics and Mathematical Modeling
Dahl, A. B., Examiner, Department of Informatics and Mathematical Modeling
Darvann, T. A., Examiner, Department of Informatics and Mathematical Modeling
Delingette, H., Examiner
Delingette, H., Examiner
Anden EU-finansiering
01/09/2012 → 30/09/2015
Award relations: Statistical Shape Modelling of the Human Cochlear with Application to Cochlear Implant Surgical Procedures
Project: PhD

**Intelligent, Interactive Templates and their Application to 3D Medical Modelling**
Darvann, T. A., PhD Student, Department of Informatics and Mathematical Modeling
Ersbøll, B. K., Main Supervisor, Department of Applied Mathematics and Computer Science
Conradsen, K., Supervisor, Department of Applied Mathematics and Computer Science
Kreiborg, S., Supervisor
Carstensen, J. M., Examiner, Department of Applied Mathematics and Computer Science
Cootes, T. F., Examiner
Mars, M., Examiner
Ansat eksternt CAMP
15/11/1999 → 28/11/2003
Award relations: Intelligent, Interactive Templates and their Application to 3D Medical Modelling
Project: PhD

**Cranio-facial growth modelling**
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Rueckert, D., Examiner
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01/12/2008 → 24/05/2013
Award relations: Cranio-facial growth modelling
Project: PhD

**Modellering af biologisk diversitet hos grise**
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Christensen, L. B., Supervisor
Aanæs, H., Examiner, Department of Informatics and Mathematical Modeling
Darvann, T. A., Examiner, Department of Informatics and Mathematical Modeling
Vangen, O., Examiner
DTU, Samfinansiering
01/02/2005 → 02/02/2009
Award relations: Modellering af biologisk diversitet hos grise
Project: PhD