KN KIEFERORTHOPÄDIE NACHRICHTEN

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A new measuring technology revolutionises the orthodontic diagnostics

Cephalometrics Without X-Rays

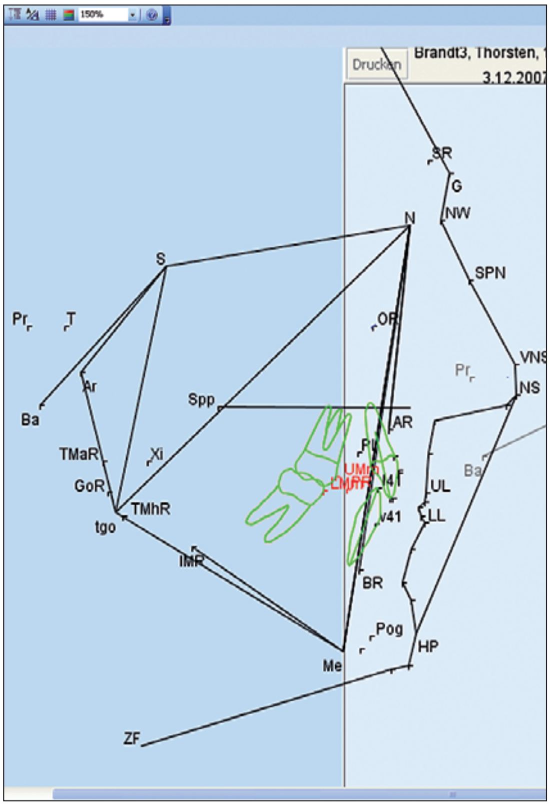
Unique, accurate and state of the art—with noXrayCeph®, the orthodontist gains a cephalometric analysis in a few minutes only that is based on magnetic induction. The hitherto unique measuring technology allows measurement of the jaw while the patient is moving, thus avoiding projection and overlapping errors caused during the evaluation of conventional lateral cephs. An article by Dr. Thorsten Brandt, M.Sc. Carmen Gunkel und Irina Buck.

Introduction

The new cephalometrics without X-rays by means of a mobile head cap (mobile measuring device) represents an alternative to classic cephalostats.

The new cephalometry is based on the three-dimensional registration in a magnetic field. The mobile carbon head cap in combination with a 3-D magnetic scanner represents a digital presentation and cephalometric analysis technology for orthodontic diagnostics, treatment plans and assessment of interim and final treatment results.

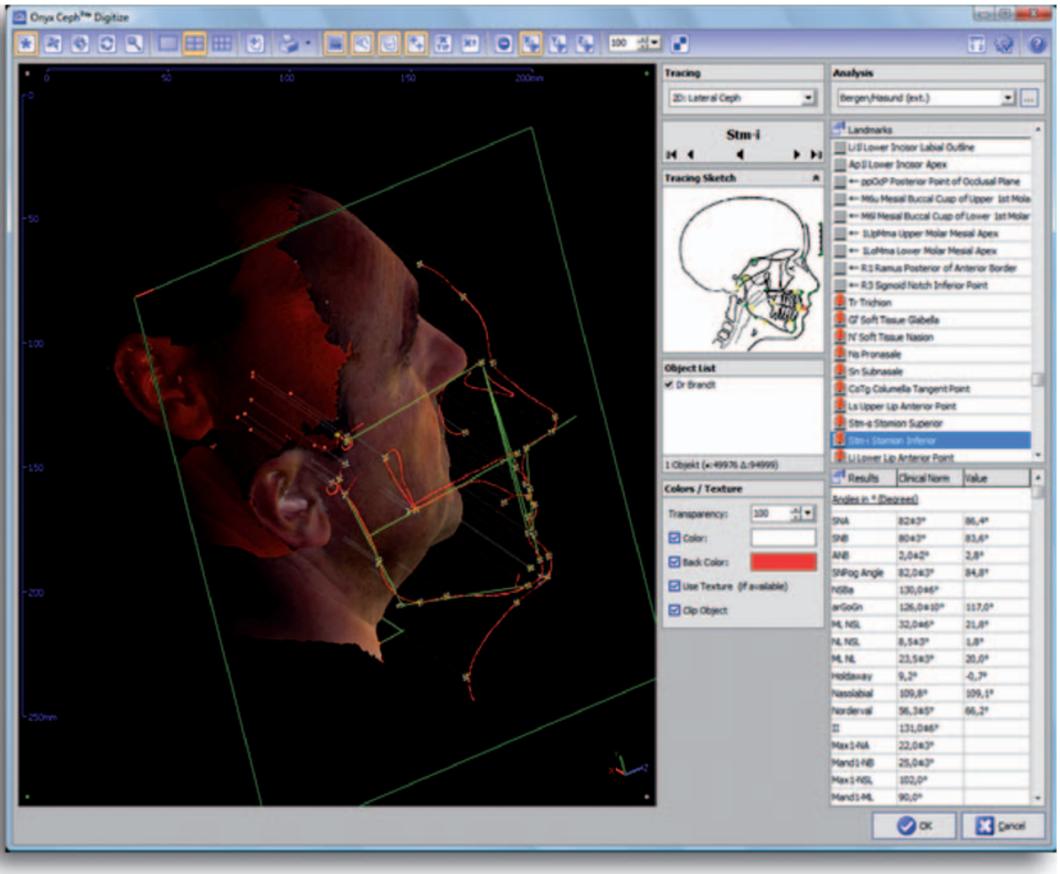
One of the problems of conventional cephalometry is the exact and reproducible positioning in the cephalostat and its verifiability, since the reproducible positioning in the cephalostat is a major criterion for the informative value of an X-ray image, according to Young-Jooh et al.[41].

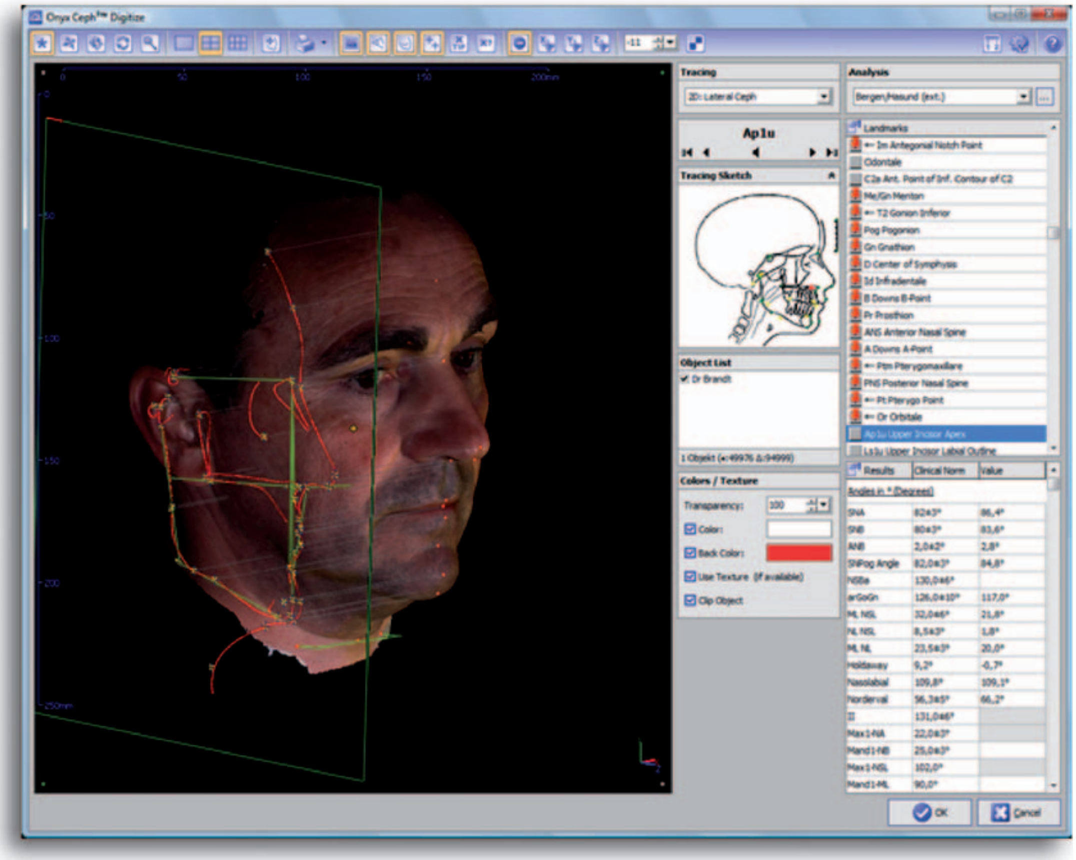


Figs. 1a and b: a): The mobile measuring device made from carbon (carbon head cap) is placed on the head. b): 55 points are measured intraorally and extraorally with the magnet stylus

The ideal case of a positioning of the projection object perpendicular to the central beam (Ahlquvist et al. 1983[1,2,3], Eliassion et al. 1982[13]) is very rare. Numerous studies covered the accuracy of the production of lateral cephalometric radiographics (lateral ceph). It was determined that the accuracy of the production of an X-ray picture mainly depends on a standard positioning of the patient. This is particularly important for the monitoring of progress of a therapy's success when

comparing the initial picture with the interim picture, since those two cannot be compared if taken in different positions[19,24]. The slightest deviations caused by an erroneous positioning of the head can already result in heavy asymmetry levels[41]. 10% of all lateral cephs have such a heavy rotation that they cannot be analysed[41]. Rotations of 4° and more result in significant changes in cephalometric values, according to Kuster et al 1989; in 10% of all cases, rotations of more than 10° were discovered[21,41]. In addition, there are major sources of error, such as the wrong positioning frequently described by Margolis[24], blurring, fuzziness, shifting due to movements during exposure, wrong development, wrong exposure, and soft parts that cannot be judged as a consequence of all of the aforementioned[23,32,37,40].
Therefore, great efforts were made to eliminate these sources of error[12].
This major source of error was to be eliminated with the new mobile head cap. This means that movements during registration (exposure) should no longer influence the celophalogram's digital construction. Furthermore, the projection was to be standardised and presented in a 1 to 1 scale in accordance with nature. This has so far not been possible with conventional technology, since different head-film distances of between 15 and 30 cm and tube distances of 1 m to 4 m (with distortions of 17.6% to 3.6%) not only make it difficult to achieve comparability, but also cause the picture itself to be distorted[20,24,32,36]. Efforts to keep distortions as little as possible result in a larger head-film distance, which causes the exposure time and radiation dose to increase. The risk of getting the pictures blurred increases with the exposure time, which results in pictures that are completely blurred, or in double pictures. Due to the radiation exposure, a second picture is often abstained from, even though the picture cannot be analysed.
Since these sources of error do not exist with the mobile measuring device, its main advantage is the individual production of a plane of projection in the middle of the cranium. Thus, the mobile measuring device's position to the cranium is no longer of importance.





Figs. 2 and 3: noXrayCeph®: unique, accurate and state of the art (3D-pictures: OnyxCeph®/3D Shape® 3D-camera)

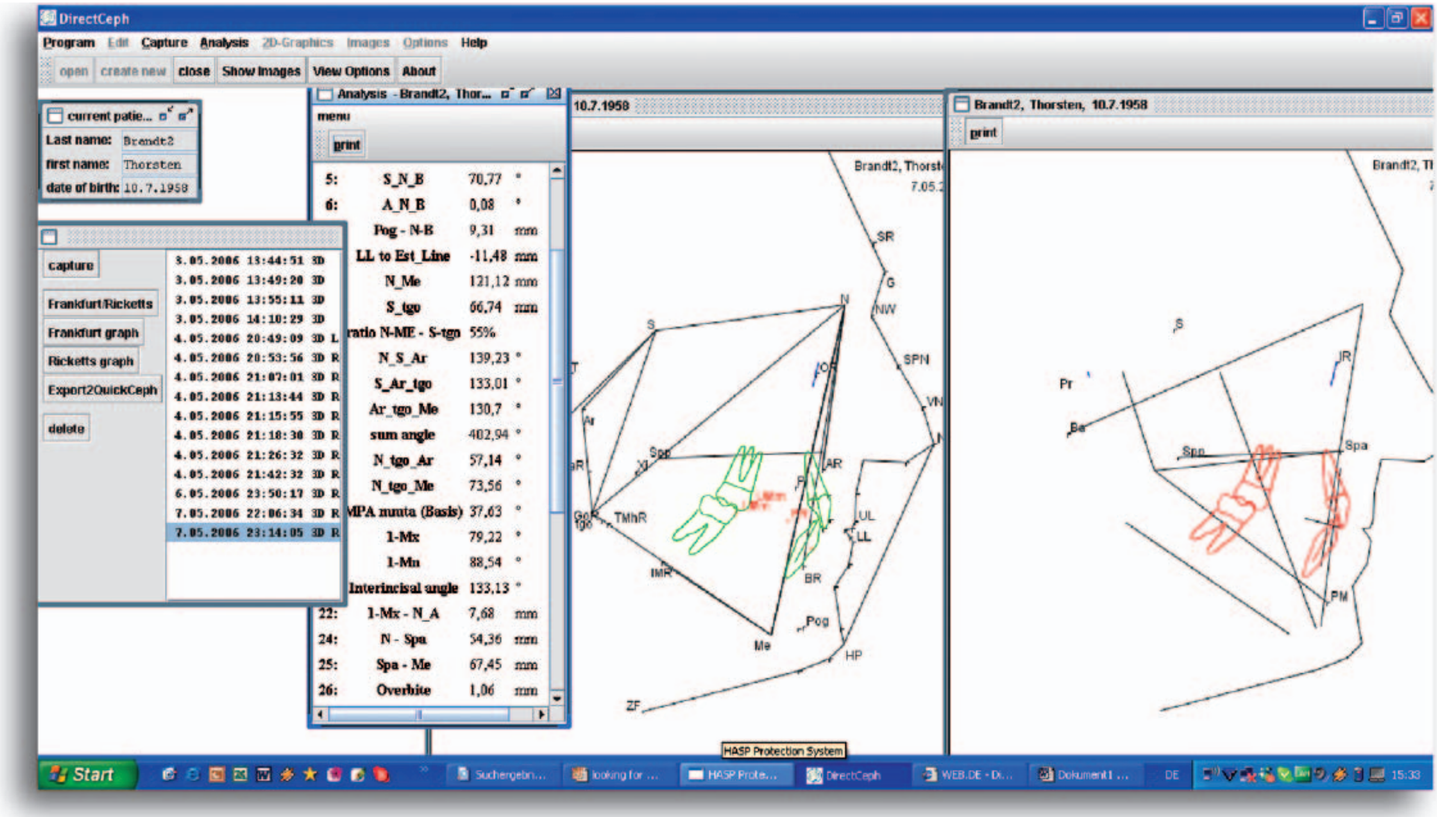


Fig. 4: A point is recorded by operating the measuring stylus and its coordinates are saved. The coordinates are entered in relation to the sensor in the carbon cap. The user is informed by an acoustic signal that a point is being recorded. If an error during the recording of a point is made, such point can individually be recorded again.

One of the mobile measuring device's potential sources of error is a moving of the ultra-light head cap during measuring. If a movement during measuring is excluded, the respective position on the head has no effect on the measuring result, since the system calibrates itself. The system finds its respective plane of projection by entering the anatomical points. Therefore, the main advantage is the mobile measuring device's ability to reproduce the measurements. The present paper investigates this reproducibility by measuring an X-ray. Since the digital line drawing of the cranium structure is automatically calculated through automatic cephalometric analysis, the measuring error common for remote X-ray taking is dispensed with due to the transmission of the X-ray image. Thus, the direct digitalisation on the patient is compared to the measuring of an X-ray image; it is, however, not possible to record the errors that are created when the X-ray image is being taken in this investigation.

Aim of the Study

The present study aimed to assess the diagnostic significance of a computer-assisted analysis by means of the mobile measuring device. In order to prove the suitability of this method for cephalometric analysis for diagnostic and planning purposes, we compared the cephalometric measurements taken on the mobile measuring device by using the noXrayCeph® software with the results from computer-assisted analyses of lateral cephs, and analysed the reproducibility of the measuring points during measurements taken with the mobile measuring device on consecutive days or different days. In addition, it was to be investigated whether the measurements taken with the mobile measuring device by two different people correlated with each other.

Material and Methods

The basic components of the system are as follows:

- noXrayCeph® scanner. In this procedure, the electromagnetic tracking system is used to determine the position of the reference points. The scanner utilises the principle of electromagnetic field coupling. The position and orientation of sensors in the space is determined by six degrees of freedom (the three x, y and z coordinates of the Cartesian coordinate system for position; azimuth, elevation and roll for orientation).
- Measuring stylus. The measuring stylus is a device with an integrated switch. The stylus' case is an electromagnetic receiver.
- The carbon headset is a receiver. It contains three electromagnetic coil springs, which create electromagnetic fields. The carbon cap is firmly mounted on the patient's head and allows free movement of the head.
- PC Microsoft Windows operating system
- noXrayCeph® software. In order to record the points and their presentation, a programme was written in the Java programming language and installed on the computer with the Microsoft Windows® operating system.

noXrayCeph® calculates the Frankfurt and Rickett analysis on the midsagittal plane, which is individually measured for each measurement, thereby constructing a new plane every time. Thus, this plane is independent of the mobile measuring device's position. It should not be moved during measuring, however; new measurements must otherwise be taken. This, however, is just a question of time and not harmful like repeated X-rays.

The drawings can be put on top of each other in case of several measurements or monitoring of progress.

The sequence of the points is as follows:

1. point: tragus right
2. point: orbita right
3. point: supraorbital foramen
4. point: nasion, compacted
5. point: tragus left
6. point: SM middle of cranium
7. point: HK, deepest insertion at the back of the cranium

Frankfurt Analysis						
			n	Mean	SD	U-Test
1: S_N_A	in degree	QuickCeph® 2000	11	74.37	0.34	
	in degree	noXrayCeph®	11	74.61	1.23	0.34
2: OK_NS	in degree	QuickCeph® 2000	11	6.7	0.87**	
	in degree	noXrayCeph®	11	7.76	2.15	0.026*
3: N_S_Ba	in degree	QuickCeph® 2000	11	148.45	0.68	
	in degree	noXrayCeph®	11	143.16	0.42	0.0004**
4: UK_NS	in degree	QuickCeph® 2000	11	40.22	3.38	
	in degree	noXrayCeph®	11	41.91	2.48	0.0938
5: S_N_B	in degree	QuickCeph® 2000	11	74.05	0.28	
	in degree	noXrayCeph®	11	71.54	0.86	0.0938
6: A_N_B	in degree	QuickCeph® 2000	11	0.44	0.34*	
	in degree	noXrayCeph®	11	3.07	0.76	0.020*
7: Distance Pog - N_B	in mm	QuickCeph® 2000	11	5.33	0.76	
	in mm	noXrayCeph®	11	5.84	0.83	
8: Distance LL to Est_Line	in mm	QuickCeph® 2000	11	-9.73	1.14	
	in mm	noXrayCeph®	11	-11	0.67	
9: Distance N - Me	in mm	QuickCeph® 2000	11	125.13	5.95	
	in mm	noXrayCeph®	11	118.94	0.98	
10: Distance S - tgo	in mm	QuickCeph® 2000	11	81.07	4.6	
	in mm	noXrayCeph®	11	69.32	1.94	
11: Ratio N_Me - S_tgo	in mm	QuickCeph® 2000	11	64.86	2.27	
	in mm	noXrayCeph®	11	58.29	1.69	
12: N_S_Ar	in degree	QuickCeph® 2000	11	147.48	0.72	
	in degree	noXrayCeph®	11	140.34	0.53	
13: S_Ar_tgo	in degree	QuickCeph® 2000	11	108.59	3.2	
	in degree	noXrayCeph®	11	127.76	3.57	
14: Ar_tgo_Me	in degree	QuickCeph® 2000	11	144.43	3.72	
	in degree	noXrayCeph®	11	132	4.25	
15: Sum angle	in degree	QuickCeph® 2000	11	399.26	4.68	
	in degree	noXrayCeph®	11	400.09	2.22	
16: N_tgo_Ar	in degree	QuickCeph® 2000	11	63.33	1.69	
	in degree	noXrayCeph®	11	58.75	2.38	
17: N_tgo_Me	in degree	QuickCeph® 2000	11	81.1	2.41	
	in degree	noXrayCeph®	11	73.32	2.39	
18: MPA mmta (Basis)	in degree	QuickCeph® 2000	11	33.52	3.66	
	in degree	noXrayCeph®	11	34.71	3.65	
19: 1-Mx	in degree	QuickCeph® 2000	11	74.26	2.11	
	in degree	noXrayCeph®	11	80.28	4.22	
20: 1-Mn	in degree	QuickCeph® 2000	11	80.02	2.98	
	in degree	noXrayCeph®	11	81.01	3.25	
21: Interincisal angle	in degree	QuickCeph® 2000	11	148.08	5.17	
	in degree	noXrayCeph®	11	148.08	4.50	
22: Distance 1-Mx - N_A	in mm	QuickCeph® 2000	11	9.08	0.66	
	in mm	noXrayCeph®	11	3.61	0.88	
23: Distance N - Spa	in mm	QuickCeph® 2000	11	53.96	2.01	
	in mm	noXrayCeph®	11	49.87	1.15	
24: Distance Spa - Me	in mm	QuickCeph® 2000	11	72.59	3.89	
	in mm	noXrayCeph®	11	70.23	1.80	
25: Overbite	in mm	QuickCeph® 2000	11	4.03	0.55	
	in mm	noXrayCeph®	11	1.24	0.83	
26: Overjet	in mm	QuickCeph® 2000	11	1.83	0.46	
	in mm	noXrayCeph®	11	1.64	1.08	

U-Test according to Mann-Whitney: * The significance level was set at $p = 0.005$. ** The result differs to a significant degree ($P < 0.01$)

Table 1: Comparison between measurements taken with QuickCeph and noXrayCeph®

Ricketts 11 Points Analysis						
			n	Mean	SD	U-Test
1: Facial axis	in degree	QuickCeph® 2000	11	93.42	0.46	
	in degree	noXrayCeph®	11	85.91	1.47	0.34
2: Facial depth	in degree	QuickCeph® 2000	11	85.85	0.72	
	in degree	noXrayCeph®	11	83.03	1.25	0.026*
3: Mandibular plane angle	in degree	QuickCeph® 2000	11	31.32	1.64	
	in degree	noXrayCeph®	11	32.37	1.80	0.0004**
4: Facial taper	in degree	QuickCeph® 2000	11	62.83	1.93	
	in degree	noXrayCeph®	11	64.83	0.83	0.0938
5: Lower face height	in degree	QuickCeph® 2000	11	40.07	1.14	
	in degree	noXrayCeph®	11	44.57	1.08	0.0938
6: Mandibular angle	in degree	QuickCeph® 2000	11	40.71	4.14	
	in degree	noXrayCeph®	11	39.66	2.13	0.020*
7: Convexity	in mm	QuickCeph® 2000	11	-2.31	0.48	
	in mm	NoXrayCeph®	11	0.07	1.47	
8: 1-Mx / A Pog	in mm	QuickCeph® 2000	11	-0.46	1.41	
	in mm	noXrayCeph®	11	-1.26	0.76	
9: 6-Mx PTV	in mm	QuickCeph® 2000	11	34.48	2.9	
	in mm	noXrayCeph®	11	33.30	1.00	
10: 1-Mn / A Pog	in mm	QuickCeph® 2000	11	14.61	4.09	
	in mm	noXrayCeph®	11	16.05	4.28	
11: LL / Est. plane	in mm	QuickCeph® 2000	11	-9.73	1.14	
	in mm	noXrayCeph®	11	-11	0.67	

* The result is significant ($P<0.05$)
* Significant values ($P<0.05$)

8. point: trichion, hair line
9. point: glabella
10. point: nasion, soft part point
11. point: BNS nose bridge
12. point: 5 mm before the tip of the nose
13. point: tip of the nose
14. point: 5 mm behind the tip of the nose
15. point: subnasale
16. point: soft part A point
17. point: UL upper lip red
18. point. middle of upper lip red
19. point: stomium
20. point: middle of lower lip red
21. point: LL lower lip, lower lip red
22. point: middle between LL and soft part B point
23. point: soft part B point
24. point: between soft part B point and pogonium
25. point: W Po, soft part pogonion
26. point: soft part gnathion
27. point: soft part menton
28. point: first cervical crease
29. point: pogonion compacted with teeth closed
30. point: gnathion, compacted with teeth closed
31. point: menton compacted with mouth closed
32. point: IM, incisura masseterica with mouth closed
33. point: tangente distal on horizontal mandibular branch
34. point: gonion with mouth closed
35. point: articular, tangent vertical branch with mouth closed
36. point: A point
37. point: incisal point 11
38. point: incisal point 21
39. point: tooth 11, furthermost labial point of tooth enamel
40.point: tooth 21, furthermost labial point of tooth enamel
41. point: tooth 11, vestibular enamel-cement-edge
42. point: palpilla incisiva
43. point: raphe mediana
44. point: mesial contact point 16
45. point: mesial contact point 46 with mouth closed
46. point: middle of first premolar tips with mouth closed
47. point: projection on the vestibular plane of tooth 41 with mouth closed
48. point: enamel-cement-edge tooth 41, mouth closed
49. point: B point, mouth closed
50. point: 41 incisal edge centre with bite block
51. point: vestibular enamel-cement-edge with bite block
52. point: B point with bite block
53. point: menton, compacted, with bite block
54. point: tangent on the horizontal branch with bite block
55. point: infraorbital point left, last point

The following analysis methods were chosen for the study: cephalometric analysis method of the University of Frankfurt am Main according to Professor Schopf and Ricketts analysis.

Software for Analysis of Lateral Ceph:

The angular and linear measurement values were determined by means of the QuickCeph®2000 (by Quick Ceph System, Inc.) software.

Study Subjects

In order to investigate the reproducibility of the measured values, a male subject (subject 1) and a female subject (subject 2) were selected, and eleven measurements each were carried out with the Mobile measuring device by two examiners. A lateral ceph was taken from subject 1 and analysed by means of the computer-assisted Quick-

Ceph® programme. The subject was measured on three different days. The examinations took place on three consecutive days: three on the first day, four on the second day and four on the third day.

Statistical Methods

The statistical analysis of the results was carried out with the Microsoft Excel® for Windows programme. The reference values were calculated by means of the mean (MEAN) and standard deviation (SD). The differences in accuracy of the lateral ceph and the noXrayCeph® were analysed with the u-test according to Mann-Whitney.

Results

The study showed that both noXrayCeph® and QuickCeph® provide reliable measurement values. Table 1 shows the differences between the means of the cephalometric variables determined by means of QuickCeph® and noXrayCeph®. In addition, the standard deviations were calculated for the reference values.

Discussion

The results of the present series of measurement have shown that the presented method is suitable to implement a reproducible cephalometric analysis in practice. In addition, it can be determined that there was no significant difference between the 1-x measurements taken directly one after another and those taken on different days in order for the method to be reproducible. The measurements, which were taken by two different people, show means that are clearly close to each other and comparable standard deviations. The present results have shown that the measurements of the front teeth are more precise than other values. This may be attributed to the hard substance points that can easily be found. This study does not include a statement on how precisely the actual cranium situation was recorded by the lateral ceph and how it can be reproduced, because patient studies to clarify this question could not be considered due to multiple radiation exposure.
By measuring the accuracy and reproducibility with the mobile measuring device system, we can go beyond the possibilities to evaluate the measuring errors of a lateral ceph. We believe that the statistical comparison of the lateral ceph analysis with the results of the measurements taken with the mobile measuring device is suitable to a limited extent only, since the description of measuring errors in a lateral ceph can only cover errors which can occur during the analysis of a picture/image. If the two-dimensional X-ray image is analysed several times and if this analysis is statistically recorded, this only covers the question how any image can be analysed analogously or after is has been digitalised on the computer. There can be numerous projection and exposure errors in the image that make an analysis useless, no matter how accurate the analysis of the "potentially crooked" X-ray image may be. The sources of error caused by positioning[41] are so serious in 10% of all X-ray images that these images cannot be analysed. In case of deviations of 4° and more, significant deviations can already be found in 4 out of 14 values. According to Bister[6], the limit for a reproducible setting in the cephalostat amounts to plus/minus 4 degrees. In studies investigating the effects of a head rotation on lateral cephs, 4 out of 10 linear and angular measurements have proven to be statistically significantly different from 4° onwards, according to Young – Jooh et al. [41]. This error is increased with each additional degree of rotation. Martins et al.[25,15] have determined that incisors, in particular, are difficult to measure both with digital and conventional lateral cephs, and that they are the source of the biggest errors and their analysis shows significant differences. Geometric image errors are imminent in each X-ray image; it is only the size of these errors that can be influenced. Enlargements and the creation of double contours created by the divergence of rays, superposition and fuzziness cannot be avoided[36]. Errors are also created by blurring, tilting of the head and different heights of the pori acusti externi. And then there are the errors later made during the analysis. Different projection distances used by different manufacturers, different anatomy of the external auditory canal, different ways of placing the patient in the cephalostat result in further differences between the X-ray images. The errors are particularly created during positioning, since the entire cephalostat has a high elasticity due to the length of its head fixation devices and its delicate structure. Another inaccuracy is created by the resilience of the soft parts. In addition, the image errors and analysis errors result in a certain inaccuracy of X-ray images. This inaccuracy becomes extreme, if a digital image is read line by line and the patient moves during the long irradiation. This source of error cannot be determined, since multiple measurements are not possible for ethical reasons. When comparing a number of measurements[30], a difference is made between random errors and systematic errors. The random errors can turn out to be very different intra-individually and inter-individually. A systematic error is given, for example, if one value is always higher than the real value. This is the case for lateral cephs when they are enlarged, which is why we are talking of a systematic error, which does not occur in case of a 1 to 1 registration. If the image is directly scanned with a 3D scanner, the distance may be longer or shorter than the real distance, thus representing a random error, which also occurs during the analysis of a lateral ceph when it is being drawn. Efforts to minimise systematic errors in lateral cephs as much as possible, e.g. by increasing the X-ray distance, are to be seen alongside the elimination of this error, since no distortions inherent in the system could be determined; see system malfunctions.
These sources of error were omitted in this paper; errors caused by retrieving points in an X-ray image were exclusively compared to errors caused by retrieving the points on the patient. Due to the high correlation of the points on the subject during repeated measurements, the software-based creation of the midsagittal plane appears to be very precise. In addition, taking X-ray images of the examined subjects appears to be a standard procedure for the members of the practice, which is what is required for reproducible images.
It seems that the described sources of error during the creation of a lateral ceph cannot be proved for magnetic cephalometry; otherwise, deviations similar to those described by Young et al.[41] should have occurred. The comparison between a lateral ceph and the mobile measuring device appears to provide a compelling argument, due to the reproducible creation of a magnetic cephalogram through precise measurements, the scanner's little technical error, as well as due to the software calculation with DirectCeph® 1.43 and, in relation to the X-ray images, the reproducible positioning in the Siemens OP 10 X-ray device and the standard analysis with QuickCeph 2000.
Thus, the cranium structure appears to be recorded in this

present study on equal cephalometric terms in the statistical sense due to a repeated calculation with magnetic analysis, which corresponds to repeated X-ray images of one of the subjects, and additionally the analysis of a lateral ceph image.
Most orthodontic patients are children and adolescents. When a growing child is exposed to radiation, such radiation has a lifelong memory effect on the hematopoietic cells in the skullcap bones. At present, the doses for lateral cephs amount to 0.05 to 1.1 mSv, to which an exposure to natural radiation sources with about 1.1 to 2 mSv per year must be added[31, 33]. It is important to keep radiation exposure as low as possible [35].
An analysis in the actual size is superior in the long run, since it shows the relations 1:1, shows the right and left side, can be repeated at any time in case the analysis is doubted and measurements of progress can be taken without any ethical problems.
The opportunity to review the lateral ceph does not exist. In order to implement a quality control similar to that of noXrayCeph®, the lateral ceph would have to be taken and measured once again. Simply analysing a lateral ceph several times does not improve its quality and even requires the image to be ideal and without errors. Simply because a control image cannot be taken for reasons of radiation protection, an assumption should not be made that the lateral ceph is the real image of the cranium structure to be measured. This assumption was developed rather by need and lack of several images than based on reality.
Due to the system's self-calibration, the measurement with the mobile measuring device is taken in real size (1:1) to the actual anatomy, which is not possible with a lateral ceph. The new volume tomography technology will enable a review of this 1 to 1 measurement method, since the relations can also be measured 1 to 1 with this technology. This method is not suitable for routine examinations, however, since the exposure to radiation is too high, particularly for adolescents and the effect on their hematopoietic cells.
With each repeated measurement, the examiner achieves the quality of a new lateral ceph and new analysis. Measurement errors are rare due to the system's accuracy. Priority is given to investigating the accuracy of the measurements taken on the subject (in a way the accuracy of the virutal lateral ceph). In a way, a new radiation-free image is created during a repeated measurement and it is sort of measured how accurately a new virtual image of the face skull matrix has been generated.
It requires some practice and routine to detect reproducible points. The staff should receive special training, since errors made during point detection have the same negative effect on the result as the analysis of a lateral ceph.
Since this method provides an opportunity for radiation-free cephalometric analysis, it is highly important for orthodontic diagnostics, therapy planning and evaluation of treatment results. The mobile measuring device enables a quick computer-assisted recording, immediate calculation and real-time drawing. Since the results are immediately printed out, no time is wasted with the development and measurement of an X-ray image. The device enables the head to move freely, thus making it possible to even measure patients that are moving around.

Conclusion

In the present study, there does not seem to be a statistical difference between the analysis of a lateral ceph

KN Short CV

Irina Buck

- 2000 Studies in computer science at Goethe University in Frankfurt am Main
- 2001–2006 Studies in dentistry at Goethe University in Frankfurt am Main
- since 2006 PhD thesis at the Preservation Dentistry department in Frankfurt am Main (Prof. Dr. D. Heidemann)
- 10/2006–9/2007 Dental Assistant at the Dr. Hartung-Hohensee group practice in Wiesbaden
- Since 1/2008 Post-Graduate Assistant at the Dr. Brandt group practice in Wiesbaden

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M.Sc. Carmen Gunkel

- Goldsmith training
- Dental technician training
- Training in dental laboratory technology at Frankfurt/Main Career Development Centre
- Studies in dentistry at Frankfurt am Main University
- Studies at the Universities of Krems/Austria and Bonn, Degree: Master of Science in Orthodontics
- Employed at the Medical Aesthetics Practice of Dr. Lohmiller in Frankfurt am Main, practice of Dr. Löffler and practice of Dr. Thorsten Brandt, Wiesbaden
- Since 1998, group practice with Dr. Thorsten Brandt
- Courses in lingual treatment, certified by Dr. Dirk Wiechmann
- Course instructor for noXrayCeph/DirectCeph certification courses
- Joint partner in the practices in Wiesbaden, Clinica Orthotec Palma de Mallorca, Cooperation Clinica Alemana Mahon in Menorca, Spain

KN Short CV

Dr. med. dent. Thorsten Brandt

- graduated from Kiel University with a PhD in 1985 (subject: „Growth Hormone Effects")
- 1992 Orthodontic Specialist, Frankfurt am Main University
- Research projects: „Accurate Dental Measurements With the Brandt-Hermanussen Device", „Bone and Growth Hormone Effects of Fluoride" at Kiel University and Loma Linda, California/USA, medical clerkship UCLA Department of Orthodontics, Prof. Turley
- Development of the Torqueontrol multi-band treatment system for programmed tooth arrangement in cooperation with Dentaurum and Frankfurt am Main University, Orthodontics department
- Development of the noXray-Ceph/Direct-Ceph System using 3-D magnetic technology, first at Frankfurt am Main University, Orthodontics department, and later on with Orthotec, Palma de Mallorca/Spain
- Private Practice Orthodontist in group practice with MSc Carmen Gunkel in Wiesbaden. Biggest achievements: our two children (10 and 12 years old).

and the measurement of the same study subject with a magnetic analysis.
This seems to be even more remarkable, since the errors caused by distortion, blurring, fuzziness and positioning when an X-ray is taken are considered to be significant.
If important statements can be made for diagnostic and planning purposes[36], provided that the lateral ceph that was taken is ideal, this statement also seems to be true for magnetic cephalometry due to the reproducibility and cephalometric values that are comparable to those of an X-ray image analysis.
Since the plane of projection is located in the cranium's real centre, a cephalometry of the right and left side of the face can be produced. Asymmetries between the right and left side of the face are thus measured in the lateral projection. Since the measurements are taken without any X-rays, as many measurements as necessary can be taken even during growth spurts or over the course of the treatment.
The mobile measuring device, which is based on magnetic technology, is a further development of cephalometric technology for orthodontic diagnostics. The device represents an alternative to the X-ray machine for the most common method—the lateral ceph.

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