Three-Year Reproducibility of Natural Head Position; A Longitudinal Study

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Abstract:
Statement of problem: Few longitudinal studies have evaluated the reproducibility of natural head position (NHP) with more than six months follow-up.
Purpose: The present investigation was conducted to estimate the reproducibility of NHP in adult cases after three years.
Materials and Methods: This descriptive study was performed on 27 volunteer dental students, 19-29 years of age. One radiograph and two photographs were taken in a NHP. The time interval between the two photographs was 4 to 10 minutes (short-term period) and a radiograph was taken approximately 2 years, 6 months after the first photograph. These were obtained by one operator and device in standing subjects. In order to evaluate NHP reproducibility, the photographs and radiographs were superimposed on the true vertical line and the angle between the true horizontal (from N') and N'-Pog' was assessed. The mean, standard deviation (SD) and confidence interval of the three angles along with short- and long-term method errors were calculated. Correlation coefficient of the angles was analyzed according to time. The differences of registration in genders were determined by t-test.
Results: Short-term reproducibility between the two photographs was 2.44º and the long term reproducibility between the first photograph-radiograph and the second photograph-radiograph was 3.23º and 3.38º, respectively. Method error in registration of NHP by photography and radiography showed no systematic bias. Gender had no significant effect on reproducibility.
Conclusion: NHP is a reproducible position in adults after 3 years. This position is more consistent in men. Photographic and radiographic registrations of NHP indicate similar results.

Key Words: Cephalometry; Photography; Radiography; Natural Head Position

INTRODUCTION
Natural head position (NHP) has been proposed as a postural basis for craniofacial morphologic analysis in orthodontic and anthropologic literature [1-3]. From the sixth decade of the 20th century, cephalometric analysis based on intra-cranial lines was introduced, but currently NHP is being increasingly used as the logical reference and orientation position for evaluation of craniofacial morphology [4-8]. NHP is a standard position with high short-term reproducibility even after fifteen years [5,9-12]. There is evidence that its variability is
significantly less than that of conventional reference lines [12-14]. Variables based on NHP better describe true-life appearance [6]. It has been proposed that NHP is correlated with craniofacial morphology [2,15], future growth trends [2,16,17], and respiratory requirements [18,19]. In addition the effect of projection errors on NHP registration is minimal [20-22]. Long-term clinical reproducibility of NHP is considered as one of its main clinical benefits; however, former studies have demonstrated contradictory results [11,15,20-22]. The fact that NHP remains stable over time, is in agreement with a study conducted by Tallgren et al [18,19] but is in contrast to the findings of Ferrario et al [22]. Several investigations have studied the reproducibility of NHP, but most are of six months duration or less [5,6,10]. The only two long-term studies are on individuals undergoing orthodontic treatment followed from childhood to adulthood [11,12].

There is still a need for further long term observations of NHP reproducibility in adults without a history of treatment.

This study was designed with the purpose of assessing the 3-year reproducibility of NHP by use of photographs and radiographs in adults without a history of orthodontic treatment in Qazvin University of Medical Sciences.

MATERIALS AND METHODS
This longitudinal descriptive study was carried out at Qazvin University of Medical Sciences, School of Dentistry and consisted of 27 volunteer dental students with an age range of 19-29 during 1998. The exclusion criteria were: congenital or TMJ disorders, history of previous orthodontic treatment, history of craniofacial surgery, and neck pain [5,9,10]. All subjects signed an informed consent, and the protocol was approved by the relevant ethical committee.

Two photographs and a radiograph were obtained in the natural head position at baseline, after 4-10 minutes and after 3 years. The mean follow up period for girls and boys was 865 and 973 days, respectively. All procedures were performed by one technician using the same device.

Photographs were taken from the subject’s left profile similar to a routine cephalogram, using a Zenith camera (Model 12XP, Russa), with a National flash and Konica 135 (iso 100/21) film.

For NHP registration, a 118×38cm mirror was placed at a distance of 150cm from the individual, vertical to the floor. The true vertical line was registered by means of a 35-cm chain with a 20 gm weight hung at its end, dividing the face into two halves. The gravity of the weight caused the chain to attain a true vertical position. The participants were asked to stand still at the time of recording in order to prevent neck bending or an unnatural head position [5,9,10].

The camera was fixed on a balanced tripod, 120cm from the face of the subjects. The position of the tripod was marked with a marker, in order to establish a fixed horizontal distance. The vertical setting of the camera was adjusted according to the height of the participants, so that the focal point was in the same direction as the subjects’ tragus. The speed and diameter of the diaphragm was identical in all cases and the same operator took all photographs.

Reference lines were drawn on tracings of the images and the two tracings were superimposed on the true vertical line (first with second). This was followed by measurement of the angle between the true horizontal line from N’ and N pog’ line.

The NHP radiograph was taken in standing position 3 years later in the same manner and using the same device. The angle was measured on the lateral cephalogram [22].

Descriptive statistics, the mean and standard deviation of head posture was calculated at a 95% confidence interval. Method error (ME) was measured by Daulberg’s formula ($S_{i1}$) and
Si(2)) \[9,12-14,17-18\].

The effect of sex on head position among the three time intervals and in each registration was evaluated with t-test. Method error between NHP photographs and the radiograph was evaluated using the statistical methods proposed by Bland and Altman [23].

RESULTS

The distributions of registration around the mean differences between photographs and radiograph in the range of two standard deviations are illustrated in Figure 1 and 2. No systematic error was seen between NHP photographs and the radiograph, but in two samples the difference was more than 2 SDs. Both subjects were females and were omitted from the rest of the statistical evaluations, reducing the sample size to 25 (11 girls, 14 boys) cases.

The mean period of long term follow-up in the 25 cases was 2 years, 6 months and 9 days; 865 and 973 days for girls and boys, respectively. The angle between \(\hat{\text{N}}\text{pog} \) and the true horizontal had a higher variance and a wider range of confidence interval when registrations were performed by radiography in girls (Table I). In boys, head extension was significantly greater in the second registration, although this trend was seen in all recording.

The short-term NHP reproducibility (Daulberg’s formula) between the two photographs was 2.44° and the long term reproductibility between the first photograph-radiograph and the second photograph-radiograph was 3.23° and 3.38°, respectively (Table II).

The effect of sex on NHP changes in all three time periods was not statistically significant. Only in the second series of photographs taken after 4-10 minutes, sex had a significant effect on head position (P=0.046) (Table II).

DISCUSSION

The present study evaluated the 3-year reproducibility of NHP by use of photographs and radiographs. In recent years orthodontic investigators have become increasingly interested in evaluating true life appearance of patients in NHP, while aesthetic and functional factors are diagnosed [6,12,14,19,22].

NHP is necessary when aesthetic evaluation of the face is required [6]. Both short-term (range, 4-10 minutes) and long-term (range, 1-
Three-Years Reproducibility of Natural Head Position

Table I: Mean, standard deviation, and confidence interval (CI) of $Npog'/TH$ (°) demonstrating head position in photographs and radiographs.

<table>
<thead>
<tr>
<th></th>
<th>First Photograph</th>
<th>Second Photograph</th>
<th>Radiograph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>91.82</td>
<td>92.61</td>
<td>91.43</td>
</tr>
<tr>
<td>SD</td>
<td>3.27</td>
<td>3.63</td>
<td>5.65</td>
</tr>
<tr>
<td>CI</td>
<td>89.93-93.71</td>
<td>90.51-94.71</td>
<td>88.16-94.69</td>
</tr>
<tr>
<td>Boys (n=14)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>89.32</td>
<td>89.27</td>
<td>91.73</td>
</tr>
<tr>
<td>CI</td>
<td>85.83-92.81</td>
<td>86.42-92.13</td>
<td>88.65-94.81</td>
</tr>
<tr>
<td>Girls (n=11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>5.19</td>
<td>4.25</td>
<td>4.58</td>
</tr>
<tr>
<td>CI</td>
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</table>

4 years) reproducibility of NHP has been evaluated. In the 25 samples of this study NHP method error was less than the variance of intracranial reference planes like SN and FH [14, 24]. The ME of other studies which were no longer than one year was between 1.43 to 4.60 [3,11,15,21,25]. The short- and long-term ME in the present study was comparable to that obtained in other investigations with the same time intervals [11,12]. We recommend photographic NHP registration because it is safe, cheap and simple. The only limitation is that it should be taken under standard conditions by a trained technician, similar to radiography [7,15]. In the current study in order to minimize projection errors a technician was trained who performed all photographs and radiographs with the same device. Considering that the participants were adults, growth changes were expected to be minimal; however continued soft tissue growth during adulthood may cause some variation in some angles, but not head posture. There is evidence that head posture is related to facial morphology [15-17]. In our investigation, a significant difference was found between sexes only in the second NHP registration in which boys had more head extension. This was also the case in the first photograph but a lower difference was observed. After three years the variability in posture increased. Extended head in males has also been reported by Ferrario [22]. Bland and Altman [23] have introduced an alternative approach to using correlation coefficients based on graphical techniques and simple calculations, to compare measurement techniques. According to their method, both photographs and radiographs produced consistent results. Ferrario [15] has also described a photographic protocol that could be used in dentistry whenever standardized views are required, especially if quantitative evaluation of craniofacial soft tissues is to be performed. The protocol is similar to the one used in the

Table II: Mean, SE and P-value of variations between genders in each of the NHP registrations and their differences.

<table>
<thead>
<tr>
<th>NHP registration</th>
<th>Mean of Differences</th>
<th>SE of differences</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>First photography</td>
<td>-2.50</td>
<td>1.70</td>
<td>0.154</td>
</tr>
<tr>
<td>Second photography</td>
<td>-3.33</td>
<td>1.58</td>
<td>0.046*</td>
</tr>
<tr>
<td>Follow up radiography</td>
<td>0.30</td>
<td>2.10</td>
<td>0.888</td>
</tr>
<tr>
<td>difference of First and second photography</td>
<td>0.83</td>
<td>1.43</td>
<td>0.566</td>
</tr>
<tr>
<td>difference of First photo and radiography</td>
<td>-2.80</td>
<td>1.79</td>
<td>0.132</td>
</tr>
<tr>
<td>difference of second photo and radiograph</td>
<td>-3.63</td>
<td>1.85</td>
<td>0.062</td>
</tr>
</tbody>
</table>

* Represent significant difference.
present study and both allow the assessment of head posture relative to the ground in sagittal views.

CONCLUSION
1- In this longitudinal photographic/radiographic study, NHP has been shown to be reproducible after 3 years and less variable than intracranial reference planes.
2- Both photographic and radiographic methods presented similar problems regarding the individual’s head position, and because photographs are simpler and more accessible they can be a replacement for registration of head position.
3- The photographic protocol introduced in the current investigation could be used in dentistry whenever standardized views are required.

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REFERENCES


