Evaluation of skin dose in a low dose spiral CT protocol

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ABSTRACT. Aim The authors evaluated radiation and skin doses absorbed by the eye lens, as well as the parotid and thyroid glands, during a low dose maxillary spiral computed tomography (CT). Methods Three spiral CTs were carried out, one after the other, changing from time to time MAS, pitch factor, Kv and consequently, CTDI/Vol, until the minimum values detectable by the equipment were reached (MAS 28, Kv 80, CTDI/Vol 2.5, Pitch 1). The quality of the images was evaluated on the grounds of being able to visualise the anatomic structures considered. The amount of radiation effectively absorbed by the soft tissue (skin doses) can be measured with the help of dosimeters placed at the level of eye lens, parotid and thyroid glands. The spiral CTs were performed with a Siemens 16 CT sensation machine, using a tissue equivalent Head-Neck RT Humanoid phantom. Results From the results of this study, it appears possible to obtain high quality images, useful for diagnosing numerous skeletal pathologies in orthodontics, reducing of about 90% the radiation dose per unit of volume and, at the same time, reducing the soft tissue (skin) dose of about 85% when compared to pre-established settings. Conclusion The authors conclude their research emphasizing the possibility of applying low dose protocols, not only in orthodontics but in any dental field, whenever a spiral CT is needed for a more detailed diagnosis.

KEYWORDS: Spiral CT, Low dose radiation protocols, Orthodontic diagnosis.

Introduction

In orthodontics, diagnosis is generally reached with the indispensable support of radiographs in all phases of patient management, including treatment planning, periodic check up, final results and follow up. Diagnostic radiology techniques are becoming more and more relevant in dentistry and nowadays this type of diagnosis is being constantly used for all types of analysis. The OPT, intraoral x-ray, spiral CT normally equipped with 3dimensional reconstruction software systems [Katsumata 2005], and RMN represent the actual state of radiological diagnostic techniques in order to obtain images of the oral-facial area.

The radiological activity in this field has been the object of numerous international trials, and the UNSCEAR committee, back in 1993, were already emphasizing the risks for young children, at the same time hoping in improvements of the procedure. The LL tele-radiograph enables to acquire accurate linear and angular measurements for diagnosing malocclusions on a sagittal and vertical plane; however, though the traditional Post-Ant radiograph works well for transversal dysplasia, it does not provide precise measurements, due to the overlapping of one or more layers on the same plane, making it difficult, even for an expert operator, to see the anatomic structure in question. Moreover, the need to carry out an early diagnosis of the anomalies on the transversal plane represents a primary objective for orthodontists. This type of early diagnosis helps preventing functional alterations that can result in unbalanced growth and, therefore, cause facial asymmetries that require surgical treatment.

The use of spiral CTs in orthodontic radiological diagnosis was proposed in 1979 by Montgomery, and again in 1982 by Timms, to assess the changes in transversal maxillary diameters after rapid palatal expansion. The spiral CT supplies clear high quality images and, therefore, a more accurate anatomical x-ray compared with the traditional Post-Ant one.

Spiral CTs make it possible to carry out real
examinations needed to evaluate the basic dimensions of the dentition [Podesser, 2004] (Fig. 1).

The only perplexity that could arise with this type of examination would be the amount of radiation needed for the scan to be carried out, especially considering the fact that orthodontic treatment usually involves young or adolescent patients. The risk factors associated with being exposed to ionized radiation, even if not yet fully defined, are quite well known and the risk of development of radio-induced tumors of the neck and head must be considered [Mailie, 1993].

For this reason, we decided to modify the standard setting of the equipment used in the Department of Radiology of the University of Messina, progressively reducing the kilovoltage (KV), Milliamp/sec (MAS) and altering the Pitch Factor in order to reduce the radiation dose index per unit of volume (CTDI/Vol) evaluating the skin doses effectively absorbed (skin dose), still obtaining high quality images.

Materials and methods

Three spiral CTs were carried out, one after the other, changing from time to time the MAS, Pitch Factor, Kv and subsequently, CTDI/Vol until the minimum values recognizable by the equipment were reached.

The amount of radiation effectively absorbed by soft tissue (skin doses) can be measured with the help of dosimeters placed at the level of eye lens, parotid and thyroid glands. The spiral CTs were performed with a Siemens 16 CT Sensation machine, using a tissue equivalent Head-Neck RT humanoid phantom. Thermo-luminescent dosimeters were used, each one having a card with various slots where different filters could be fitted, and two sensors were positioned into them (lif pills: mg, cu, p gr-200 a). The correct reading of the card (using a rados-dosacus-tid reader) and the software system that converts the LED dose signal is guaranteed by the localized light beam (doserad ii) with a sit commencer at the centre; 20ugy was the minimum legible dose, 10% max. per dose of uncertainty; <5% reproducible. The scanogram dose was also taken into consideration (Fig. 2).

The quality of the images was assessed on the basis of information believed to be useful for orthognathodontic diagnosis. The possibility of performing linear and angular measurements, in order to determine the various levels of maxillary and mandible transversal width, nasal cavity width and the inclination of teeth, is indispensable.

Unlike previously published studies, no evaluation scales were applied [Cohnen, 1998; Lorenzen, 2005]. Table 1 shows the MAS, Pitch Factor, Kv and CTDI/Vol used for the 3 tests

Results

Table 2 and Figure 3 show the results obtained. The results show that it is possible to obtain high quality images useful for diagnostic purposes, reducing by about 90% the amount of radiation per unit of volume and about 85% for skin dose compared to the standard maxillary spiral CTs. The same results, from a study carried out in 1996 by Diederichs et al., have already been published.
Conclusions

With the help of low dose spiral CT protocols, it is possible to acquire high quality images ideal for formulating a more accurate orthodontic diagnosis, especially for transversal dysplasia, thus substituting the traditional Post-Ant tele-radiography where superimposing, in front of and behind the same plane, makes it difficult even for an expert operator to visualise the anatomic structures in question.

Even if the patient is exposed to a higher dose of radiation compared to a traditional Post-ant radiography, a low dose protocol, like the one used in this study, helps in obtaining reasonably low radiation and skin dose. The dosage is low enough to avoid high radiation risks for the patients. Moreover a computed tomography scan enables us to obtain not only a 3-dimensional reconstruction, which in the long run can be used for further diagnosis, but also a Panorex reconstruction. Therefore it is possible, when deciding to perform a spiral CT, to avoid the use of a panoramic x-ray, which is the usual routine for orthodontic check ups.

In the light of this consideration, it would be worthwhile establishing with the radiologist low dose spiral CT protocols that could be used in any field of dentistry, especially for children, when a detailed diagnosis is needed. Hence the radiography timing for some frequently observed pathologies should be reconsidered, such as condylar intra-capsular fractures, impacted teeth etc.

Considering the low dose spiral CT as first approach, it is possible to replace the traditional panoramic x-ray, that does not allow to perform a three dimensional diagnosis. Low dose visualise the topographic relationships between anatomic structures.

<table>
<thead>
<tr>
<th>MAS</th>
<th>PITCH</th>
<th>CTDI/ vol. m/ grey</th>
<th>KV</th>
</tr>
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<tbody>
<tr>
<td>High</td>
<td>100</td>
<td>0.42</td>
<td>22.68</td>
</tr>
<tr>
<td>Medium</td>
<td>50</td>
<td>0.42</td>
<td>11.49</td>
</tr>
<tr>
<td>Low</td>
<td>28</td>
<td>1</td>
<td>2.5</td>
</tr>
</tbody>
</table>

**TABLE 1 - Different resolution TC.**

**Table 2 - Results.**

<table>
<thead>
<tr>
<th></th>
<th>CT High Res. mGy</th>
<th>CT Medium Res. mGy</th>
<th>CT Low Res. mGy</th>
<th>Reduction %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right eye lens</td>
<td>6.25</td>
<td>4.65</td>
<td>1.8</td>
<td>68.96</td>
</tr>
<tr>
<td>Left eye lens</td>
<td>9.05</td>
<td>4.35</td>
<td>1.71</td>
<td>78.56</td>
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<tr>
<td>Thyroid gland</td>
<td>4.18</td>
<td>1.88</td>
<td>0.68</td>
<td>98.08</td>
</tr>
<tr>
<td>Right parotid gland</td>
<td>30.2</td>
<td>18.6</td>
<td>3.71</td>
<td>90.99</td>
</tr>
<tr>
<td>Left parotid gland</td>
<td>31.3</td>
<td>19.2</td>
<td>2.44</td>
<td>90.47</td>
</tr>
</tbody>
</table>

**FIG. 3 - Graph showing the results obtained.**

**FIG. 4 - High resolution scan.**
such as the mandible canal, maxillary sinus, etc. Whenever it is necessary to make a qualitative evaluation of poor contrasting structures, such as spongy bone during the pre-operative planning of oral implant surgery, it is necessary to perform high resolution tests.

References