Mandibular Cortical Width on Panoramic Images of Children in the Lao People’s Democratic Republic

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Abstract: The purpose of this study was to determine correlations between height and weight with mandibular cortical width (MCW) that may aid identification of bone mineral density (BMD) in a pediatric population. A total of 122 patients (69 boys and 53 girls) aged 4 to 6 years old who were patients at the Dental Hospital of Faculty of Dentistry (UHS, Lao P.D.R.) participated in the study. Anthropometric data of height and weight were recorded. Digital panoramic radiographs were taken and transferred to Nihon University, Tokyo via telemedicine system. MCW was measured using a SDS-DICOM viewer application. The Mann-Whitney U test was performed to analyze MCW gender differences. Tukey-Kramer method was performed to determine means of MCW, Height, Weight between each age group. The Pearson’s correlation test was performed to analyze the correlation between MCW and Height or Weight. P values less than 0.05 were considered statistically significant. The range of MCW were between 1.40-3.03 mm in males and 1.68-2.80 mm in females, with no sexual differences. As age increased, each parameter (MCW, Height, Weight) increased, but no significant difference between age groups was detected in MCW. There were positive significant correlations between height and MCW, but not between height and MCW. This pilot study has shown that MCW does not appear to be a useful indicator for the diagnosis of hidden children osteogenesis. Further studies are needed to examine if other panoramic radiomorphometric indices could be more relevant.

Key words: Mandibular cortical width, Height and weight, Panoramic radiography, Children, Laos

Introduction

On December 31, 2015 the ASEAN Economic Community (AEC) was established within the larger ASEAN Community to promote the free flow of goods, services, investment and skilled labor, and to enable the freer movement of capital across the region. The AEC also identified 8 professions, including dentistry, that can operate within the 10 member nations. The economic development of the Lao People’s Democratic Republic (Laos) lags behind its ASEAN neighbors, and is reflected in an overall lower quality of public health care. In 2014 the total population was 6,809,054 including cohorts of children aged 0-4 (14.1%) and 5-9 (12.6%) respectively. There are approximately 500 dentists in the whole country; a ratio of one dentist per 14,000 head of population. Laos has only one national dental school located in the capital, Vientiane. The school lacks many modern dental facilities, such as Computer Tomography (CT scan) or Cone Beam Computed Tomography (CBCT), which are widely used in other nations for accurate diagnosis and treatment planning. The school does own and operate a digital panoramic radiograph machine, donated by Nihon University School of Dentistry in 2000.

Osteoporosis is a major public health problem confronting both developed and developing countries. Osteoporosis can affect both children and adults, and is especially detected in postmenopausal women. The typical clinical presentation of osteoporosis is the radiographic detection of bone fractures, largely in the absence of causative trauma. These fractures occur due to a reduction in bone mineral density and a general reduction in bone mass. Osteoporosis is usually diagnosed by measuring bone mineral density (BMD) of the spine or femur. Dual energy X-ray absorptiometry (DXA) is recommended for precise diagnosis of low bone mass. No DXA equipment is currently available in Laos.

Like other bones in the body, the jaw bones can also be affected by systemic diseases, including osteoporosis. Most of the research carried out on mandibular bone has revealed a relationship between osteoporosis and oral bone loss mainly employing conventional dental radiography, not quantitative CT (QCT) or DXA. Densitometric and morphometric indices such as Mandibular Cortical Index, Simple Visual Estimation, Mandibular Cortical Width, Mental Index, Mandibular Cortical Thickness, Panoramic Mandibular Index, Gonial Index, Antegonial Index have been developed from panoramic radiographs to support a diagnosis of osteoporosis, and have been utilized worldwide.
MCW has been shown to be a good measure of bone mass in the mandible compared with the other indices. Sisou ethn et al. have reported that the overall average MCW of 519 Laotian patients aged 7-79 years was lower than that observed in Europeans. They proposed that this difference may be due to different nutrition and climatic conditions. No average MCW for Laotian preschool children has been reported.

Nutrition is the intake of food, considered in relation to the body’s dietary needs. Good nutrition – an adequate, well balanced diet combined with regular physical activity – is a cornerstone of good health. According to the Convention on the Rights of the Child every infant and child has the right to good nutrition. Yet globally in 2013, 161.5 million children under 5 were estimated to be stunted, 50.8 million were estimated to have low weight-for-height (particularly in South-central Asia countries), and 41.7 million were overweight or obese. In Laos, 48% of under five-year-old children were classified as stunted, 10% wasted and 44% underweight. Compared to other developing countries in South-East Asia and globally, these figures are very high. These documented national figures are matched by local experience. The Maternal Newborn and Children’s Hospital have reported that one-third of the mortality among children under-five years of age in Laos was due to undernutrition. Severe malnutrition, especially in infancy, may affect bone formation.

The main objective of this study was to establish a Laotian child MCW standard and investigate the relationship between MCW and anthropometrics of height and weight in children aged 4 to 6 years of age to determine whether MCW could be helpful in estimating the status of osteogenesis.

### Materials and Methods

The study population consisted of a total of 122 Laotian children patients (age 4-6 years; 69 males and 53 females) who had received a panoramic radiographic examination at the Department of Pedodontics, Faculty of Dentistry, University of Health Sciences, Vientiane Capital, Lao P.D.R. between June and August 2015 as part of the diagnosis of multiple severe caries. This was a cross-sectional study. Verbal informed consent was obtained from the parents of all patients. Parents were interviewed to gather general demographic and health information. Any children who had either severe localized or systemic diseases were excluded from the study. Digital measurement apparatuses were used to measure body height and weight of each child employing prescribed clinic protocols. Panoramic radiographs were taken with a Veraviewepocs CCD digital panoramic imaging device (Morita Corporation, Kyoto, Japan) with exposure control in the automatic mode.

Images were exported as DICOM image stacks to the Department of Oral and Maxillofacial Radiology, Nihon University School of Dentistry, by a telemedicine system with functions for image viewing, image transfer, DICOM storage real-time video conferencing, and

### Table 1. The number of subjects by age and sex

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>male</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>male</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>male</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>male</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>53</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MCW (mm)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>4 (n=42)</td>
<td>2.10 (1.40-2.75)</td>
<td>104.02 (80.0-120.0)</td>
</tr>
<tr>
<td>5 (n=45)</td>
<td>2.15 (1.68-3.03)</td>
<td>112.42 (102.0-125.0)</td>
</tr>
<tr>
<td>6 (n=35)</td>
<td>2.19 (1.43-2.98)</td>
<td>118.00 (111.0-130.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age</th>
<th>MCW</th>
<th>Height</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-5</td>
<td>0.043</td>
<td>8.398</td>
<td>1.550</td>
</tr>
<tr>
<td>p-value</td>
<td>0.794</td>
<td>0.000*</td>
<td>0.002*</td>
</tr>
<tr>
<td>4-6</td>
<td>0.083</td>
<td>13.976</td>
<td>4.226</td>
</tr>
<tr>
<td>p-value</td>
<td>0.461</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
<tr>
<td>5-6</td>
<td>0.041</td>
<td>5.578</td>
<td>2.676</td>
</tr>
<tr>
<td>p-value</td>
<td>0.825</td>
<td>0.000*</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* Significant difference was detected between age groups (p<0.05)
Correlation between the MCW and Height or Weight. P values less than 0.05 for Pearson's correlation coefficient (r) were used to assess the strength of the difference between the age groups in the parameter measured. Subsequently, the Tukey-Kramer method (Table 3) was used to compare the mean of MCW and the anthropometric characteristics of height and weight in each age group. Each parameter was measured using the SDS-DICOM Viewer application on a PC monitor in a dark room. A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line perpendicular to this tangent intersecting inferior to the mental foramen was constructed, from which mandibular cortical bone thickness was measured. The values were rounded up to the second decimal place. Radiographs were excluded from the study if the images showing inferior cortical borders were of poor quality or otherwise unreadable to allow proper measurements of mental foramen regions. MCW on both right and left sides of mandibles of 122 Digital Panoramic Radiographs were measured by two experienced oral and maxillofacial radiologists. Each observer independently measured bilateral MCW and then calculated an average MCW. The mandibular cortical width was measured in the region of mental foramen as previously reported by Taguchi et al.15,17.

**Table 4. Correlations between Height, Weight and MCW among Lao children aged 4-6 years old**

<table>
<thead>
<tr>
<th>Anthropometric Parameter</th>
<th>r</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>0.201</td>
<td>0.026*</td>
</tr>
<tr>
<td>Weight</td>
<td>0.177</td>
<td>0.051</td>
</tr>
</tbody>
</table>

* = Pearson's correlation coefficient. 

**Table 5. WHO child malnutrition estimates of ten countries in South-East Asia 2015 edition**

<table>
<thead>
<tr>
<th>Country</th>
<th>Year survey</th>
<th>Income Region</th>
<th>Sample Size (N)</th>
<th>Wasting (%)</th>
<th>Stunting (%)</th>
<th>Underweight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>2009</td>
<td>High</td>
<td>1,196</td>
<td>2.9</td>
<td>19.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Cambodia</td>
<td>2014</td>
<td>Low</td>
<td>4,893</td>
<td>9.6</td>
<td>32.4</td>
<td>23.9</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2013</td>
<td>Lower middle</td>
<td>75,232</td>
<td>13.5</td>
<td>36.4</td>
<td>19.9</td>
</tr>
<tr>
<td>Laos</td>
<td>2011-2012</td>
<td>Lower middle</td>
<td>10,826</td>
<td>6.4</td>
<td>43.8</td>
<td>26.5</td>
</tr>
<tr>
<td>Malaysia</td>
<td>2006</td>
<td>Upper middle</td>
<td>5,546</td>
<td>-</td>
<td>17.2</td>
<td>12.9</td>
</tr>
<tr>
<td>Myanmar</td>
<td>2009-2010</td>
<td>Lower middle</td>
<td>15,430</td>
<td>7.9</td>
<td>35.1</td>
<td>22.6</td>
</tr>
<tr>
<td>Philippines</td>
<td>2013-2014</td>
<td>Lower middle</td>
<td>-</td>
<td>7.9</td>
<td>30.3</td>
<td>19.9</td>
</tr>
<tr>
<td>Singapore</td>
<td>2000</td>
<td>High</td>
<td>16,220</td>
<td>3.6</td>
<td>4.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Thailand</td>
<td>2012</td>
<td>Upper middle</td>
<td>8,874</td>
<td>6.7</td>
<td>16.3</td>
<td>9.2</td>
</tr>
<tr>
<td>Vietnam</td>
<td>2013</td>
<td>Lower middle</td>
<td>99,421</td>
<td>5.7</td>
<td>19.4</td>
<td>12.1</td>
</tr>
</tbody>
</table>

*Country sharing.*

This study was approved by the Ethics Committee in the Faculty of Dentistry, Laos University of Health Sciences (Approval No.0003, year 2015).

**Image analysis and measurements**

Mandibular bone mass was assessed by measuring the cortical width in the mental foramen region, as shown in Fig. 1. The MCW was measured using the SDS-DICOM Viewer application on a PC monitor in a dark room. A line parallel to the long axis of the mandible and tangential to the inferior border of the mandible was drawn. A line perpendicular to this tangent intersecting inferior to the mental foramen was constructed, from which mandibular cortical bone thickness was measured. The values were rounded up to the second decimal place. Radiographs were excluded from the study if the images showing inferior cortical borders were of poor quality or otherwise unreadable to allow proper measurements of mental foramen regions. MCW on both right and left sides of mandibles of 122 Digital Panoramic Radiographs were measured by two experienced oral and maxillofacial radiologists. Each observer independently measured bilateral MCW and then calculated an average MCW. The mandibular cortical width was measured in the region of mental foramen as previously reported by Taguchi et al.15,17.

**Statistical analysis**

Data entry and analyses were performed using Microsoft Excel and Statistical Package (SPSS, version 21; IBM Corporation, Armonk, NY, USA), respectively. The Mann-Whitney U test was used to compare sex differences of MCW values. Subsequently, the Tukey-Kramer method was applied to determine whether there was a statistical difference between the age groups in the parameter measured. Pearson’s Correlation Coefficient (r) was used to assess the strength of the correlation between the MCW and Height or Weight. P values less than 0.05 were considered statistically significant.

**Results**

122 children (69 boys and 53 girls) aged 4, 5 and 6 years’ patients participated in this study (Table 1).

The overall average of MCW among Laotian Children aged 4 to 6 years was 2.14±0.31 mm (range 1.40-3.03). The average MCW in males was 2.15±0.31 mm (range 1.40-3.03) and in females, 2.14±0.31 mm (range 1.68-2.80), indicating that the cortical bone at mental foramen region was thicker in males than in females but not significantly so (Table 2) by Mann-Whitney U test (p=0.965). No sexual dimorphism was observed in MCW in this sample population.

The mean of MCW and the anthropometric characteristics of height and weight in each age group are shown with their differences between each age group by Tukey-Kramer method (Table 3). Each parameter increased with increasing age. The mean MCW in each age group increased slightly, by 2.10 mm, 2.15 mm and 2.19 mm respectively, but there were no statistically significant differences between each age group of age 4 to 5 years (p=0.794), age 4 to 6 years (p=0.461) and age 5 to 6 years (p=0.825). In contrast, the average height and weight of the children presented statistically significant differences year by year.

Pearson’s correlation coefficients (r) were calculated to assess the interrelationship between MCW and the anthropometric measures of height and weight (Table 4). There was a significant positive statistical correlation only between MCW and height, but not between MCW and weight (p<0.05).

**Discussion**

Osteoporosis is a silent disease often only revealed by bone fractures following minimal trauma. It can be prevented, diagnosed and treated before any fractures occur.31 Compared with adults, osteoporosis is relatively uncommon in children. Osteoporosis can occur as a primary bone disorder or emerge secondary to other diseases and/or treatment. The disease in childhood has two primary forms; osteogenesis imperfecta and idiopathic juvenile osteoporosis. Secondary pediatric osteoporosis occurs most frequently because of immobilization and as a result of long-term steroid treatment for a variety of chronic diseases.29 Human growth, which refers to an increase in anatomic size and the growth-timing of skeletal tissues, varies both within and between subjects. For example, craniofacial bone growth is about 45%
completed by birth, 70% completed by 7 years of age and for some continues to grow through puberty. Childhood bone development is extremely important and is influenced by diet and nutrition. Any disturbances in growth patterns could predispose children to bony defects, low BMD, high bone turnover or high risk of osteoporotic fracture.

This study investigated the MCW of a sample of 4 to 6 year old preschool children. DXA is the most commonly used densitometry technique for children throughout the world and is the recommended modality for clinical assessment of bone density. However, BMD measurement by DXA and QCT are not widely available in developing countries, because of cost and lack of equipment. No suitable machines are available in Laos. A number of studies have indicated that a dental panoramic radiograph may be a suitable tool to measure bone mineral densities.

In this study digital panoramic radiographic equipment was used to obtain the images. Digital panoramic technologies have the benefit of eliminating errors associated with processing and providing the opportunity of using digital enhancement and measuring tools. Digital panoramic radiography also limits radiation exposure as it requires a lower dose than conventional panoramic radiography for image formation. In this study digital panoramic images were obtained with a CCD-based digital panoramic unit. Software-based contrast, brightness and measurement facilities were used for evaluation of images.

Leite et al. tested for correlation of panoramic radiomorphometric indices with BMD and the accuracy of these indices for predicting osteoporosis. They recommended that the most accurate index for identifying osteoporosis in women was the MI, which is the same as MCW used in this study.

Some investigators have proposed a computerized method to measure MCW automatically on digital panoramic radiographs. This study did not apply a computer-aided diagnostic system to detect MCW automatically. These systems encounter difficulty in identifying the mental foramen region when its image is overlapped by permanent tooth germs in mixed dentition or when the cortical edge border is unclear radiographically.

In our findings the overall MCW of Laotian children aged 4 to 6 years of age was 2.14±0.31 mm (range:1.40-3.03) (Table 2). The average MCW in males was 2.15±0.31 mm and 2.14±0.31 mm in females, indicating the cortical bone width was almost the same, with no significant sexual dimorphism. Average MCW did increase every year although the statistically significant difference in mean MCW values between each age could not be detected.

In 2015, Sisounthone et al. established the average MCW in 519 Laotian subjects (age 7-79 years; mean 38.21 years). According to those results, average MCW values showed significant differences between all age groups. The average MCW in the youngest age group of 7-19 years was 2.90±0.81 mm (range:1.50-5.80), which was higher than the data obtained for the 4 to 6 years age group in this study. Sisounthone et al. also described a statistically significant sexual dimorphism in overall average MCW. In summary, the MCW of Laotian children from 4 to 6 years of age increases slightly, but changes more significantly following adolescence.

Aboishi et al. reported the average MCW of a group of Japanese children aged 4 to 6 years, as reported on the web page Archive for International Cooperation in Education organized by Center for Research on International Cooperation in Educational Development, University of Tsukuba. The average MCW of 65 Japanese preschool children was 2.16±0.31 mm (range:1.40-3.10). The difference between Laotian and Japanese MCW values was statistically significant by ANOVA (F=293.03; p<0.001). The Laotian mandible cortical bone was thinner than that of Japanese children aged 4 to 6 years indicating a significant ethnic difference. Benson et al. analyzed the different osteoporosis critical risk between women of Northern European and Mediterranean descent. There is paucity of equivalent literature establishing standard population correlates of radiomorphometric indices with BMD in the Southeast Asian region. It would be appropriate to utilize the mandibular radiomorphometric indices for diagnosis of osteoporosis and low bone mass in ASEAN regions, and it would be beneficial to prepare measurement ranges across populations, including ethnic subgroups.

Normative data for BMD values in children, and the influence of growth parameters, have been reported. Height and weight are reported as highly dependent parameters on BMD. This study measured average MCW and anthropometric measures of height and weight in Laotian preschool children and analyzed correlations between height and weight with MCW. The children’s growth factors were estimated against WHO standards for ‘wasting’, ‘stunting’ or ‘overweight’. Compared to the WHO child malnutrition estimates among ten countries of the AEC (Table 5), Laos was in the median range for ‘wasting’ (6.4%), but had the highest prevalence in the categories of ‘stunting’ and ‘underweight’ (43.8% and 26.5%, respectively). These findings correspond to the recent reports of Sayasone et al. who found that amongst 464 children under 5 years old in the southern part of Laos 13.6% exhibited ‘wasting’, 46.3% ‘stunting’ and 35.3% ‘underweight’.

In this study the sample population was from the urban city of Vientiane where the negative growth indicators of under 5-year-old children were quite low. There were no ‘underweight’ children, and ‘wasting’ and ‘stunting’ were each measured at 4.8%. Previous reports on the nutrition status of Lao children have shown significant differences between subgroups of children. The lower rates of negative growth indicators in the urban environment may reflect improvement in the nutritional status in the past 10 years in the city, a large proportion of people with diverse ethnic backgrounds or a combination of both.

In conclusion, MCW standards for Laotian preschool child at Vientiane have been established. MCW increased slightly with increasing age but with no significant difference between age groups. In addition, the positive correlation between MCW and Height was significant, but no significant correlation was detected between MCW and Weight. These results suggest that MCW in this period is not a useful indicator for the diagnosis of hidden children osteogenesis. Consequently, further studies are needed to examine if other panoramic radiomorphometric indices could be more relevant.

Acknowledgment
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Competing interests
The authors have declared that no COI exists.

Reference


