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Modified method of dental age estimation of Malay juveniles

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1. Introduction

Age estimation has its major application in anthropology, archaeology, forensics, clinical medicine and dentistry. In countries where registration of birth is routine and legally enforced, there is usually no need for its estimation as the chronological age (CA) is certain. However, many countries do not have an organised birth record keeping. There have been many cases when false documents were used to substantiate the claim of age of an individual. There were also incidences when documents of birth date appeared to be inconsistent with the physiological stage of the person they represent. Therefore under such instances, it becomes necessary to perform age assessment, by using scientific data, charts or surveys to determine the CA of a person [1,2]. In forensic application, when dental identification is performed, dental age (DA) estimation is one important criterion used to identify deceased persons [3]. In clinical dentistry, the information on DA assists in diagnosis and treatment planning, particularly in the paediatric dentistry and orthodontic areas of specialisation [2,4]. Teeth are preferred in age estimation because they are virtually immune to mechanical, chemical or physical corrosions [5]. They are capable of remaining intact even when other bone structures have disintegrated [6]. The stages of dental calcifications are least susceptible to environmental influences and are also independent of the individual's somatic growth [7].

Some researchers estimate the CA by using a combination of methods. These include clinical and radiological observations of the stages of development of teeth, secondary sex characteristics, fusion of hand and wrist, fusion of sterno-clavicular bones, fusion of cranial sutures, changes in pubic symphysis and anterior iliac crest, changes in cranial size, and the degree of occlusal tooth wear [4,8]. Relevant information for dental age estimation include development of teeth, rate of formation of incremental structures in the tooth crown, changes in the pulpo-dentinal complex, changes in the chemical composition of dental tissues, the fluorescence of dental hard tissues, and dental attrition [9]. Dental age estimation can be conducted in several ways, the most simple and effective methods are based on the phase of tooth eruption/emergence or development pattern of the dentition [9,10]. The precise time of tooth eruption/emergence is very difficult to determine as this is comparatively a fleeting event. Conversely, tooth calcification is a continuous process, which allows it to be measured as an indication of physiological maturity. Shamim et al. suggested separating age estimation into three phases: firstly, the prenatal, neonatal and early postnatal phase; secondly, children and adolescents; and finally the adults [11].

Tooth development may be evaluated using radiological methods. These may involve the use of dental radiographs that are either extra-oral or intra-oral. The earliest signs of tooth mineralization are identified from the appearance of radiopaque spots prior to the calcification of the tooth cusps and crown formation, subsequently leading to root development and closure of the root apex [12]. Estimation of age of living people is mainly performed using the dental panoramic tomographs (DPTs) based on the assessment of the teeth mineralization stage [13]. It has been adopted by most investigators for their accessibility and ability to visualize all teeth on a single radiograph with minimal distortion [14]. In addition, estimation of age from dental radiograph is simpler and the least invasive compared to biochemical and histological methods that involve laborious laboratory procedures [15].

Demirjian's method widely used DPTs for comparing various populations and it defines the tooth mineralization stages and assigns them according to pre-determined scores [16]. Demirjian's scores were originally derived from a French-Canadian population. The procedure in obtaining the score for each stage is based on the Tanner scale for skeletal age [17]. In addition, Healy and Goldstein (1976) provided an explanation for the calculation [18]. The use of Demirjian's maturity

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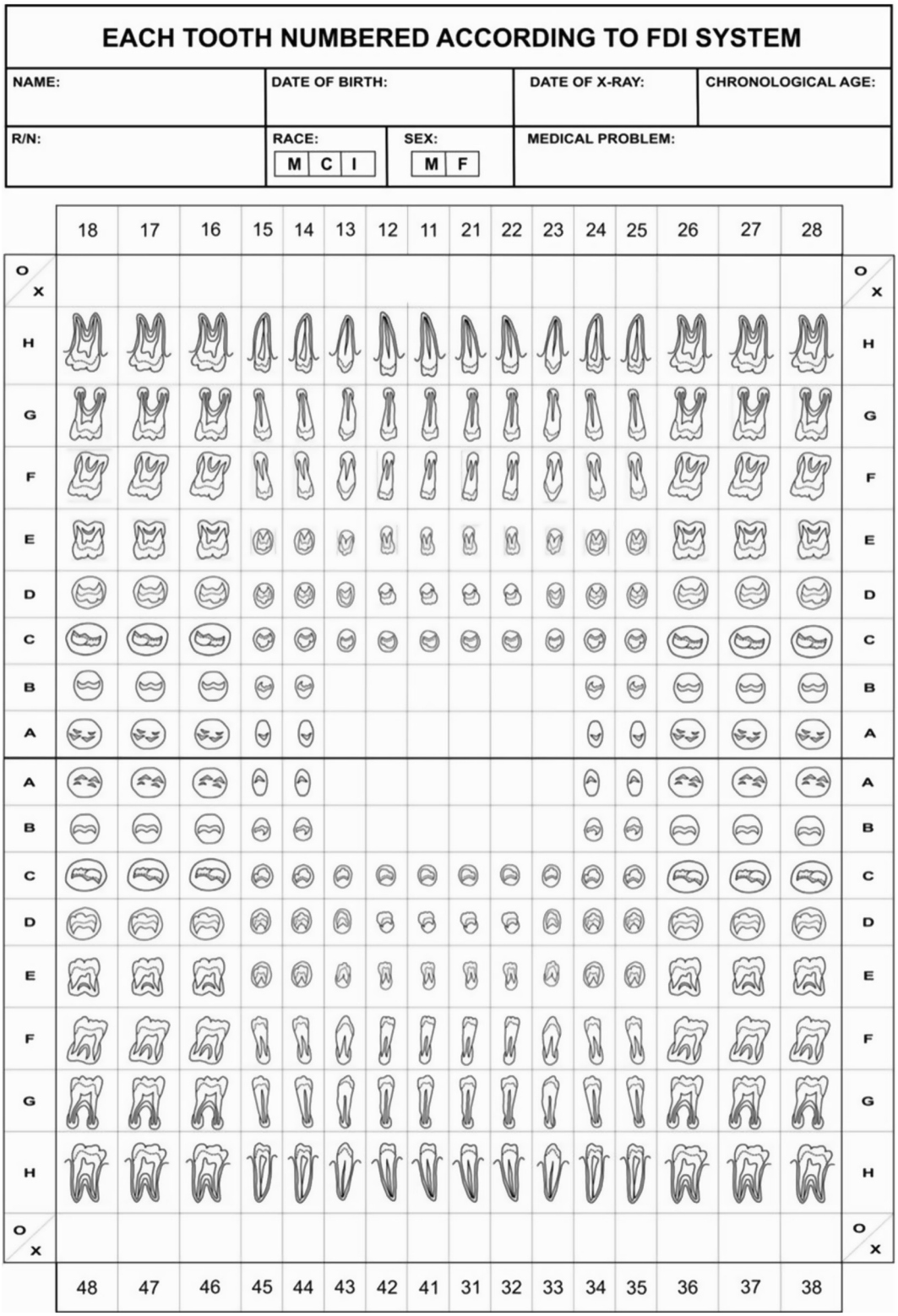

Fig. 1. Dental age chart used in this study, after Demirjian et al. [16].

scale in different populations around the world has revealed that some populations share similar patterns of dental maturity attainment as the French-Canadians, whereas other populations differed significantly. This trend was observed in ethnically dissimilar populations and populations within a same geographical area [9,19]. This highlights the limited applicability of such reference data.

In the last two decades, Artificial Neural Networks (ANN) may probably be the single most successful technology which has been widely used in a large variety of applications in various areas. An ANN is a mathematical model that tries to simulate the structure and functionalities of biological neural networks. ANNs are able to "learn" an approximate non-linear relationship between inputs and outputs using algorithms designed to alter the strength (weights) of the connections in the network to produce a desired signal flow. This "training" process is