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ScienceDirect

Journal of the Chinese Medical Association 81 (2018) 842–847

www.jcma-online.com

Original Article

Comparing the reliability and accuracy of clinical measurements using plaster model and the digital model system based on crowding severity

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Received July 19, 2017; accepted November 21, 2017

Abstract

Background: This study aims to clarify whether 3Shape™ digital model system could be applied in orthodontic diagnostic analysis with certainty, especially under different crowding condition. Reliability, accuracy and efficiency of 3Shape™ digital model system were assessed by comparing them with traditional plaster cast.

Methods: 29 plaster casts with permanent dentition were transformed into digital models by 3Shape™ D800 scanner. All 29 models were categorized into mild-crowding (arch length discrepancy <3 mm), moderate-crowding (arch length discrepancy >3 mm and <8 mm), and severe-crowding group (arch length discrepancy >8 mm). Fourteen linear measurements were made manually using a digital caliper on plaster casts and virtually using the 3Shape™ Ortho Analyzer software by two examiners. Intra-class Correlation Coefficient (ICC) was used to evaluate intra-examiner reliability, inter-examiner reliability and reliability between two model systems. Paired t test was used to evaluate accuracy between two model systems. Kruskal–Wallis test followed by Mann–Whitney U test was used to evaluate the measurement differences between 3 groups in two model systems.

Results: Both intra-examiner and inter-examiner reliability were generally excellent for all measurements made on 3Shape™ digital model and plaster cast (ICC: 0.752–0.993). Reliability between different model systems was also excellent (ICC: 0.897–0.998). Half of the accuracy test showed statistically significant differences ($p < 0.05$) when digital models were compared with plaster casts. Furthermore, while assessing measurement differences between 3 groups in two model systems, the mandibular required space showed significant difference ($p = 0.012$) between mild crowding group ($0.27 + 0.01$ mm) and severe crowding group ($0.20 + 0.09$ mm). However, the differences were less than 0.5 mm and would not affect clinical decision.

Conclusion: Using 3Shape™ digital model system instead of plaster casts for orthodontic diagnostic measurements is clinically acceptable.

Keywords: Dental models; Imaging; Three-dimensional

1. Introduction

Successful orthodontic treatment is based on comprehensive diagnosis and treatment planning, and model analysis is a vital part for correct diagnosis. However, traditional plaster models have some shortcomings, such as storage space required, durability, and inefficient in terms of retrieval and transfer.

Conflicts of interest: The authors declare that they have no conflicts of interest related to the subject matter or materials discussed in this article.

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https://doi.org/10.1016/j.jcma.2017.11.011

1990 digital model system OrthoCad™ was first introduced as a commercial product. After that, different digital model systems: such as E-model™, Suresmile™, Orthoproof™ and Ortholab™ came to the market from worldwide.

To testify the accuracy of digital model system replacing traditional plaster cast in orthodontic field, several studies had been performed for different digital model systems including OrthoCad™ system,[1−7] E-model™.[8,9] Most authors concluded these systems are valid alternative to traditional plaster study models in orthodontic diagnosis.

Aside from pure digital model service, some systems also provide accompanied software for orthodontic usage, one of which is 3Shape™ (Copenhagen, Denmark). From literature review, Lemos et al.[10] used R700 scanner (3Shape™) to transform plaster cast into digital model and test measurement reliability with 3Shape™ software by six selected measurements. Reuschl et al.[11] further investigated the reliability and validity of clinical measurements made on 3Shape™ digital models of dentition with no crowding or mild crowding. Anh et al.[12] compared the accuracy of two intraoral scanner scanning systems under four crowding situations and found larger scanning inaccuracies under severe crowding conditions.

Syed et al.[13] had evaluated the measurements accuracy and duration between 3Shape software (orthosystem) and plaster cast, the models were divided into 3 groups based on severity of crowding (group 1: <2.5 mm, group 2: 2.5−5 mm, and group 3: >5 mm). The results showed no statistically significant difference between the mesiodistal width measurements, arch length discrepancy and Bolton's values in all the three groups. However, space discrepancy >5 mm is not the condition we suspect to obstruct light from scanner. Severe crowding in our patient population are majority, and accurate space analysis for orthodontic diagnosis and treatment plan making are crucial.

Therefore, this study aims to clarify whether 3Shape™ digital model system could be applied in orthodontic clinical diagnosis with certainty, especially under real severe crowding condition.

2. Methods

Twenty-nine pretreatment diagnostic study model sets were enrolled in this study by stratified random sampling method. The subjects were classified into three groups according to the degree of crowding on single arch (minor crowding, arch length discrepancy <3 mm; moderate crowding, arch length discrepancy >3 mm and <8 mm; and severe crowding, arch length discrepancy >8 mm). Each stratum contains 9−10 sets of models.

These models were selected by 2 criteria: (1) Complete permanent dentition and fully eruption from first molar to first molar; (2) All teeth had normal morphology and no obvious dental abnormalities. All 29 plaster model sets were digitized using a D800 Scanner (3-shape™, Copenhagen, Denmark).

Two measuring methods were used: (1) measuring with digital caliper (accurate to 0.01 mm; Shanghai Taihai Congliang Ju Co., Lcd, Shanghai, China), (2) measuring digital model using 3shape™ measuring software (Ortho Analyzer), the computer was 14-inch screen with 1600 × 900-pixel resolution and 64-bit color. The zooming and rotation function were applied during virtual model analysis. Two well-trained examiners (L.R. and Y.L.) used both methods to do twelve horizontal measurements and two vertical measurements (#11 crown height and #35 crown height) (Table 1).

The two examiners took the measurement independently under a standardized workflow, and the required time was recorded. All measurements were performed to the nearest 0.01 mm.

Table 1
Measurement definition.

Variable	Definition
Max required space	Summation of the mesiodistal width of maxillary right and left first and second premolar, canine, lateral incisors and central incisors
Mand required space	Summation of the mesiodistal widths of mandibular right and left first and second premolar, canine, lateral incisors and central incisors
Max available space	Measured the parameters by the segmented arch approach with six segments from mesial side of maxillary right first molar to mesial side of left first molar.
Mand available space	Measured the parameters by the segmented arch approach with six segments from mandibular right first molar mesial side to left first molar mesial side.
Anterior Bolton	Percentage obtained by summing the width of the 6 mandibular anterior teeth divided by the by the sum of the widths of 6 maxillary anterior teeth
Overall Bolton	Percentage obtained by summing the width of the 12 mandibular teeth (first molar to first molar) divided by the by the sum of the widths of 12 maxillary teeth (first molar to first molar)
Overbite	Greatest amount of vertical overlap between upper and lower central incisors.
Overjet	Distance from the labial surface of the most anterior lower incisor to the labial surface of the most anterior of upper incisor.
Max inter-canine width	Distance between the cusp tip of maxillary canines
Max inter-molar width	Distance between the mesiobuccal cusp tip of maxillary first molars
Mand inter-canine width	Distance between the cusp tip of mandibular canines
Mand inter-molar width	Distance between the mesiobuccal cusp tips of mandibular first molars
11 crown height	Measured from the incisal edge to the gingival margin along the long axis of the maxillary right central incisor
35 crown height	Measured from buccal cusp tip to the gingival margin along the long axis of the mandibular left second premolar