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Digital models in orthodontic diagnosis: a review

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Abstract

Objective: the purposes of this review is to evaluate the validity and reliability of orthodontics measurements on digital models

Materials and methods: rating of studies present in literature from 2003 to 2016, that evaluate the validity and reliability of orthodontic space analysis on digital models.

Results: digital models represents a valid alternative to plaster models in the orthodontic diagnostic process. In the most of studies the measurements results underestimated but the differences are clinically insignificant.Â

Introduction

Dental study models are a cornerstone in the armamentarium used by orthodontists to both classify malocclusion and formulate treatment plans. The information obtained from this dental casts is invaluable to help in the orthodontic diagnosis and plaster models have been the standard for years, since their introduction in the 1700s. Philip Pfaff first described an impression-taking technique by using heated sealing wax to obtain a negative representation of dental arches that was used to pour a cast in plaster of Paris. In the mid-19 century, others materials such as plaster of Paris, gutta-percha and thermoplastic modeling compound became popular for taking impression and after in the early 1900s has been introduced the reversible hydrocolloid alginate and later irreversible hydrocolloid alginate that is yet used nowadays (1).

Dental models can be used to evaluate the occlusion and perform measurement more easily and accurately than in the patient's mouth. Measurements typically made for orthodontic diagnosis are overjet, overbite, tooth sizes, arch lengths and transversal distances. Space can be analyzed byÂ calculating the arch length discrepancy. Disproportions among sizes of maxillary and mandibular teeth can be defined by using the tooth size discrepancy calculations according Bolton. These measurements are realized by hand on plaster models by using a caliper and require an accurate impression of patientâ€™s dentition for the fabrication of plaster models.

In the new digital era, various technological advancements have made their way into dental practices and the past decade has seen the advent of digital models. The introduction of digital models offers to the orthodontist a valid alternative to the plaster models routinely used. In relation to that, digital models overcome a lot of disadvantages offered by plaster cast. They are not subject to physical damage and do not create any dust or other mess. They also require negligible storage space. The digital information for each case can be stored on an office computerâ€™s hard drive and is less than 1 megabyte in size. The software programs required to view these digital models are 8 to 12 megabytes in size. Retrieval is fast and efficient because the models are stored by patients name and number; it is possible to view digital models at multiple locations from any office computer linked to the practice's central server. The electronic files can be transferred electronically to colleagues, other specialist and insurance companies and so decrease the time and expense of model duplication and shipment. In addition to all of this advantages, digital models are also an excellent tool for patient education and improve the communication between the clinicians and patients, enhancing informed consent. Ultimately, digital modes can be virtually manipulated, precise cross-section views can be created, and they can be magnified. The only disadvantage is the cost: they are more expensive than plaster cast and require specifics tools and software to their realization. There are currently 3 methods to produce digital 3D models: laser scanning of plaster models and alginate impression, CBTC scans and CBCT scanning of alginate impressions or plaster models (13) and direct intraoral scanning of the dentition.

The purposes of this review is to evaluate the validity and reliability of orthodontic measurements on digital models used in orthodontic diagnosis.

Materials and Methods

It was realized a search on Pubmed by using key word like "digital models and orthodontic" and "measurement on digital models". ItÂ been made a selection of all the studies that evaluate the validity and reliability of digital study models measurement realized in orthodontic diagnosis process, from 2003 to 2016.Â

Discussion

Space analysis is a critical step in orthodontic diagnosis mostly when determining whether extractions are necessary to accommodate a crowed dentition. So, if we wanted to use digital models in this process, its important evaluate their validity and reliability. In the most of studies evaluated the orthodontic measurements were underestimated (2-3-4-5).Â S. R. Mullen et al. (2) showed any significant differences between the Bolton ratios calculated using plaster models and digital models, but theyÂ founded differences in the calculation of arch length and tooth structure in both arches: the measurements on digital models resulted 1,5 mm smaller than that measured on the plaster models. This founding is in agreement whit Schirmer and Wiltshire(6), that showed the digitized measurements to be smaller than the manual measurements. They attributed this to the difficulty of measuring a 3D model in 2 dimensions, because of the convex structure of the teeth, the curve of Spee and the differences in inclination of the teeth. According to S.R. Mullen, this difference in the measurements between caliper and software could be attributed to several factors; one was the difficulty of finding the greatest MD width of teeth with the software. In some cases the interproximal area between the teeth is not well defined enough and the operator will tend to underestimate the measurement, leading to a discrepancy of about 1,5 mm less tooth structure in each arch. The difference of 1,5 mm could be clinically insignificant, because according to Profit(7) a tooth size difference of less than 1,5 mm is not considered significant. In addition to this studies , Santoro et al. (3) and D. R. Stevens et al.(4) reported digital tooth measurements that were always smaller. If one assumes that digital model is accurate in size, the most likely explanation for the difference is that digital models result in more valid measurements than plaster because there is no physical barrier of the caliper dictating placement of measurements points.; so, it was be reasonable to believe that digital measurements are more valid than those made by calipers on plaster. A.M.R. Cuperus et al. (8) reported that the measurements errors on the digital models were smaller than were those on the skulls and the stereolithographic models. So digital model measurements showed better reproducibility than traditional caliper measurements, even if the measurements tended to be smaller than those on the skulls. J. Czarnota et al. (5) showed that all parameter evaluated(MD crown widths, overjet, overbite, midline discrepancy, maxillary intercanine and intemolar distances) were underestimate on digital models and this supports the finding by Abizadeh (9).Â The largest of differences found to be statistically significant in measuring tooth widths were 0,2 mm and according to AmericanÂ Board of Orthodontics objective grading system, vertical, transverse and anterior-posterior deviations < 0,5 mm are clinically insignificant (10). F. Zhang et al. (11) reported a statistically significant difference in intermolar distanceÂ measurementsÂ between plaster model and digital models and this might cause by a distortion in scanning of dentition. However in the other measurements there wasn't any significant differences. Â UltimatelyÂ it is important underline that measurements made either manually on plaster models or digitally on a computer are subject to inter-examinerÂ variability (12). Manual measurements with digital caliper depend on the positioning of the ends of the caliper on plaster model. For digital measurements, the examiner must indicate on a computer screen the 2 points to be connected as the tooth width. So the differences in the results of the latest studies can be related also to that.

Conclusion

Digital models represents a valid alternative to the plaster models in the orthodontic diagnostic process, because they showed a lot of advantages like negligible storage space, fast and efficient retrieval, absence of physical damage, easy transfer and tool of patient education, but above all they showed a validity and reliability in the measurements used in the orthodontic diagnostic process.

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