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From Physical to Digital: A Comparative Analysis of Dental Measurements

Abstract:
Background: Modern orthodontics increasingly embraces digital technologies to enhance diagnostic accuracy and treatment planning. Three-dimensional (3D) digital models created from intraoral scans are one of these innovations that present a strong substitute for conventional plaster models. Through a direct comparison of linear measures taken from digital and traditional plaster models, this study seeks to assess the accuracy and dependability of digital dental models as a diagnostic tool.
Method: For each type of model, measurements were taken on all teeth from the first molar to the first molar in both the maxilla and mandible, and three primary parameters—mesiodistal width (MD), buccolingual width (BL), and cervico-incisal height (CI)—were measured on the clinical crowns of individual teeth. In total, 20 sets of models were made, 10 sets of plaster models and 10 sets of digital models. Plaster models were made from alginate impressions, and the digital models were generated using an iTero intraoral scanner.
Results: Statistical analysis demonstrated no significant differences in linear measurements between plaster and digital models, indicating a high degree of agreement. Minor discrepancies were observed but deemed clinically insignificant.
Conclusion: Digital dental models demonstrate comparable accuracy to traditional plaster models for linear measurements, supporting their reliability as a diagnostic tool in orthodontics. This finding suggests the potential for digital models to replace plaster models, offering a more efficient and patient-friendly approach without compromising diagnostic accuracy.

Key-words: dental study model;digital study model; intraoral scanner; tooth measurements

Introduction:

Orthodontics focuses on diagnosing, preventing, and treating dental and facial irregularities, relying heavily on precise measurements for treatment planning and achieving optimal smiles.[1] Traditionally, physical plaster models crafted from alginate impressions have been the gold standard for such measurements,[1,2] enabling orthodontists to evaluate tooth size, position, and inter-arch relationships. These models, introduced in the 18th century, underwent significant advancements in materials and techniques over the 19th and 20th centuries.[3]

Plaster models offer a three-dimensional representation of a patient's occlusion, making them valuable for assessing progress and maintaining records. However, they come with limitations: impression-taking is prone to errors, models are fragile and require careful storage, and physical transportation for consultations can be inconvenient and time-consuming.

With the advent of digital dentistry in the 21st century, intraoral scanners are replacing traditional plaster models.[4] These scanners capture accurate three-dimensional digital impressions, enhancing patient comfort and reducing chairside time.[5] Digital models are durable, free from breakage concerns, and facilitate easy sharing for treatment planning and appliance fabrication.[6]

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While digital models offer numerous advantages, debates about their accuracy compared to traditional plaster models persist. Ongoing research continues to compare the reliability of linear measurements between the two, particularly for applications like orthodontic appliances or crown preparations. The shift from plaster to digital models represents a significant transformation in orthodontic practice, streamlining workflows and improving patient care.

Purpose of research :

This study evaluates the effectiveness of digital dental models in orthodontics by comparing linear measurements from traditional plaster models and intraoral scan-generated digital models. It aims to assess the accuracy and reliability of digital models in replicating essential diagnostic data.

I. Materials and Methods:

The study included 10 participants aged 15–25 years who met specific inclusion criteria, such as mild dental spacing or crowding with fully erupted permanent teeth. A total of 20 models were created: 10 plaster models and 10 digital models.

Plaster Models:

- Impressions: Alginate impressions were taken using Coltene alginate and perforated metal stock trays to enhance retention. The integrity and expiration date of the alginate packaging were checked before use.
- Transportation: Impressions were promptly secured and transported to the laboratory
- Casting: Models were cast using Orthocal stone plaster, known for its off-white color, high strength, and high expansion properties.

Digital Models:

- Scanning: Intraoral scans were conducted using the iTero Intra oral scanner. Teeth surfaces were dried with compressed air to ensure accuracy, and scans were performed with sterile scanner heads. Scanning began in the right maxillary quadrant and followeda systematic sequence.
- Measurement: Virtual models were measured on the GOM Inspect software.

Measurement Process:

Three key parameters were measured on clinical crowns of individual teeth:

1. **Mesiodistal Width (MD):** Measured as the widest distance between contact points.

Maxilla: From the upper right first molar (tooth 16) to the upper left first molar (tooth 26).

Mandible: From the lower left first molar (tooth 36) to the lower right first molar (tooth 46).

2.Buccolingual Width (BL): Measured as the widest distance between buccal and lingual surfaces in the occlusal plane, with caliper arms aligned parallel to the tooth's long axis.

3.Cervico-Incisal Height (CI):

Incisors: From the gingival line to the incisal edge.

Canines and Premolars: From the gingival line to the cusp tips.

Molars: From the gingival line to the occlusal surface using the buccal groove as a reference.

Measurement Tools:

Plaster Models: Measurements were taken with an electronic caliper (accuracy: 0.01 mm, range: 150 mm).

Digital Models: Measurements were taken using GOM Inspect software, with designated points marked and connected to record lengths for MD, BL, and CI.

This methodical approach ensured accurate and consistent measurements across both model types.

Statistical Analysis:

Statistical analysis was performed using an independent t-test for mesiodistal and buccolingual lengths between the models and GOM Inspect methods. The Mann-Whitney test was used for cervicoincisal measurements. Intraclass correlation coefficients (ICC) wee calculated to assess the agreement between the two methods for maxillary and mandibular teeth measurements.

II. Results:

Table 1 compares the mean values of various orthodontic measurements in the maxillary (upper jaw) region, highlighting the consistency between the "Models" and "GOM Inspect" methods.

Table 1. Comparison of mean values of the measurements in maxilla among two methods

Measurement	Models		GOM inspect		Difference	p-value
	Mean	SD	Mean	SD		
MD	7.071	1.178	7.071	1.193	0.000	1.000#
BL	7.551	1.562	7.553	1.575	-0.002	0.992#
CI	6.936	1.868	6.936	1.866	0.000	0.940¥

#Independent t test; ¥Mann Whitney test

For the mesiodistal (side-to-side) measurement, both methods reported an identical mean value of 7.071 mm, with standard deviations of 1.178 (Models) and 1.193 (GOM Inspect). The difference between the mean scores was 0.000 mm, which was statistically insignificant (p = 1.000).

Similarly, for the buccolingual (front-to-back) measurement, the mean values were 7.551 mm (Models) and 7.553 mm (GOM Inspect), with standard deviations of 1.562 and 1.575, respectively. The negligible difference of 0.002 mm was also not statistically significant ($p = 0.992$).

In the cervico incisal (crown height) measurement, both methods again reported an identical mean value of 6.936 mm, with standard deviations of 1.868 (Models) and 1.866 (GOM Inspect). The mean difference of 0.000 mm showed no statistical significance ($p = 0.940$).

These results demonstrate a high degree of accuracy, reliability, and interchangeability between the two methods for measuring orthodontic parameters in the upper jaw.

Table 2 compares the mean values of various orthodontic measurements in the mandibular (lower jaw) region, highlighting the consistency between the "Models" and "GOM Inspect" methods.

Table 2. Comparison of mean values of the measurements in mandible among two methods

Measurement	Models		GOM inspect		Difference	p-value
	Mean	SD	Mean	SD		
MD	6.574	1.679	6.598	1.673	-0.024	0.914#
BL	6.812	1.529	6.802	1.527	0.010	0.960#
CI	6.697	1.328	6.718	1.312	-0.021	0.873¥

#Independent t test; ¥Mann Whitney test

For the mesiodistal (side-to-side) dimension, the mean values were 6.574 mm (Models) and 6.598 mm (GOM Inspect), with standard deviations of 1.679 and 1.673, respectively. The difference between the two methods was 0.024 mm, which was statistically insignificant ($p = 0.914$).

In the buccolingual (front-to-back) measurement, the mean values were 6.812 mm (Models) and 6.802 mm (GOM Inspect), with standard deviations of 1.529 and 1.527, respectively. The minor difference of 0.010 mm was also not statistically significant ($p = 0.960$).

For the cervico incisal (crown height) dimension, the mean values were 6.697 mm (Models) and 6.718 mm (GOM Inspect), with standard deviations of 1.328 and 1.312, respectively. The difference of 0.021 mm was statistically insignificant ($p = 0.873$).

These results confirm a high degree of reliability, accuracy, and interchangeability between the two methods for assessing orthodontic parameters in the lower jaw.

Table 3 highlights the reliability analysis of the two measurement methods for maxillary (upper jaw) teeth.

Table 3. Reliability analysis of two methods for maxillary teeth measurements

Measurement	ICC	p-value
MD	0.998	<0.001*
BL	0.999	<0.001*
CI	0.999	<0.001*

ICC: Intraclass correlation coefficient

For the mesiodistal (side-to-side) measurement, the intraclass correlation coefficient (ICC) was 0.998, indicating almost perfect agreement between the methods ($p < 0.001$).

The buccolingual (front-to-back) measurement also demonstrated almost perfect agreement, with an ICC of 0.999 ($p < 0.001$).

Similarly, the cervico incisal (crown height) measurement showed an ICC of 0.999, reflecting nearly perfect agreement ($p < 0.001$).

These results confirm an almost perfect agreement between the two methods across all parameters (mesiodistal, buccolingual, and cervico incisal) for the maxillary teeth.

Table 4 presents the reliability analysis of the two measurement methods for mandibular (lower jaw) teeth.

Table 4. Reliability analysis of two methods for maxillary measurements

Measurement	ICC	p-value
MD	0.999	<0.001*
BL	0.999	<0.001*
CI	0.998	<0.001*

ICC: Intraclass correlation coefficient

For the mesiodistal (side-to-side) measurement, the intraclass correlation coefficient (ICC) was 0.999, indicating almost perfect agreement between the methods ($p < 0.001$).

The buccolingual (front-to-back) measurement also demonstrated an ICC of 0.999, showing almost perfect agreement ($p < 0.001$).

For the cervico incisal (crown height) measurement, the ICC was 0.998, reflecting nearly perfect agreement between the two methods ($p < 0.001$).

These findings confirm an almost perfect agreement between the two methods across all parameters (mesiodistal, buccolingual, and cervico incisal) for the mandibular teeth.

I. Discussion :

Digital scans have revolutionized dentistry by streamlining data transfer, expediting diagnoses, and facilitating rapid treatment planning.[7] Lukasz et al even observed that younger patients preferred intraoral scanners over alginate impressions, despite the latter requiring less time. This preference was attributed to the queasiness experienced during alginate impression-taking.[8] Furthermore, a Canadian survey revealed that most dentists believe digital technology enhances efficiency.[7]

Liu et al noted that digital scans were reliable against conventional plaster models.[9] Michael et al. discovered no statistically significant difference in mandibular arch space, which is in line with our study's finding that there is no statistically significant difference between physical and digital models. However, they noted a significant difference for the maxillary arch.[10]

The equivalency of digital and physical models was also supported by Devan Naidu, who found statistically significant variances between the two but stressed that these differences were not clinically important. Unlike our findings, where digital and physical measurements alternated in being slightly higher, Devan Naidu reported digital models being consistently larger than caliper-measured values.[11] Abizadeh, also presented a contrasting view, asserting that digital models lack reliability due to inaccuracies stemming from improper 1:1 scaling.[12]

These findings highlight the varying perspectives on the precision of digital dental models and their clinical applicability.

II. Conclusion:

This research highlights a strong agreement between tooth size measurements obtained from digital and plaster models, with any minor variations being clinically insignificant. This firmly establishes digital models as a reliable tool in modern dentistry, enhancing not only accuracy but also organization and efficiency. The transition to digital platforms ushers in a new era of collaborative and innovative dental practices, with the ease of replicating and sharing digital models opening up promising opportunities for education and clinical research. The future of dentistry is undeniably digital, offering exciting possibilities where technology and healthcare seamlessly integrate to deliver optimal patient care.

Potential avenues for further study:

While this study supports the accuracy and reliability of digital dental models for orthodontic diagnosis, further research is needed to fully integrate them into clinical practice. Larger and more diverse sample sizes are required to confirm their generalizability across different populations, considering factors like malocclusion severity and craniofacial morphology. Additionally, exploring the integration of digital models with emerging technologies such as artificial intelligence, 3D printing, and virtual reality could enhance their utility, particularly for automated landmark identification and creating patient-specific appliances.

References:

1. Proffit WR, Fields H, Larson B, Sarver DM. Contemporary Orthodontics-E-Book: Contemporary Orthodontics-E-Book. Elsevier Health Sciences; 2018 Aug 6.
2. Shillingburg HT, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. Hanover Park, IL: Quintessence Publishing Company; 2012.
3. Mahesh Verma B. 19th century denture base materials revisited. Official Publication of the American Academy of the History of Dentistry www.historyofdentistry.org. 2011;59(1):1.
4. Formicola AJ, Bailit HL, Weintraub JA, Fried JL, Polverini PJ. Advancing dental education in the 21st century: phase 2 report on strategic analysis and recommendations. Journal of dental education. 2018 Oct;82(10):eS1-32.
5. Joda T, Bragger U. Digital vs. conventional implant prosthetic workflows: a cost/time analysis. Clinical oral implants research. 2015 Dec;26(12):1430-5.
6. Kardach H, Szponar-Żurowska A, Biedziak B. A comparison of teeth measurements on plaster and digital models. Journal of Clinical Medicine. 2023 Jan 25;12(3):943.
7. Neal G. Palmer, James R. Yacyshyn, Herbert C. Northcott, Brian Nebbe, Paul W. Major, Perceptions and attitudes of Canadian orthodontists regarding digital and

electronic technology,American Journal of Orthodontics and Dentofacial Orthopedics,Volume 128, Issue 2,2005,Pages 163-167,ISSN 0889-5406,https://doi.org/10.1016/j.ajodo.2005.02.015

8. Lukasz Burhardt, Christos Livas, Wouter Kerdijk, Wicher Joerd van der Meer, Yijin Ren,Treatment comfort, time perception, and preference for conventional and digital impression techniques: A comparative study in young patients, American Journal of Orthodontics and Dentofacial Orthopedics,Volume 150, Issue 2,2016,Pages 261-267,ISSN 0889-5406,https://doi.org/10.1016/j.ajodo.2015.12.027 .
9. Liu J, Liu Y, Wang J, Zuo X, Wang X, Zhang Y, et al. Dental measurements based on a three-dimensional digital technique: a comparative study on reliability and validity. Arch Oral Biol 2021;124:105059.
10. Michael F. Leifert, Melvyn M. Leifert, Stella S. Efstratiadis, Thomas J. Cangialosi,Comparison of space analysis evaluations with digital models and plaster dental casts, American Journal of Orthodontics and Dentofacial Orthopedics,Volume 136, Issue 1,2009,Pages 16.e1-16.e4,ISSN 0889-5406,https://doi.org/10.1016/j.ajodo.2008.11.019 .
11. Leifert MF, Leifert MM, Efstratiadis SS, Cangialosi TJ. Comparison of space analysis evaluations with digital models and plaster dental casts. Am J Orthod Dentofacial Orthop. 2009;136(1):16e1-16e4
12. Devan Naidu, Terrence J. Freer, Validity, reliability, and reproducibility of the iOC intraoral scanner: A comparison of tooth widths and Bolton ratios,American Journal of Orthodontics and Dentofacial Orthopedics,Volume 144, Issue 2,2013,Pages 304-310,ISSN 0889-5406, https://doi.org/10.1016/j.ajodo.2013.04.011 .
13. Abizadeh, N., Moles, D. R., O'Neill, J., & Noar, J. H. (2012). Digital versus plaster study models: How accurate and reproducible are they? Journal of Orthodontics, 39(3), 151–159. https://doi.org/10.1179/1465312512Z.0000000003