



Digital versus Manual Assessment of Arch Dimension Changes Following Four First Premolar Extraction in Bimaxillary Protrusion

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ABSTRACT

Background: Bimaxillary protrusion is commonly managed with extraction of four first premolars to facilitate retraction and retroclination of the anterior teeth. Changes in arch dimensions following extraction treatment are clinically relevant to treatment stability and smile esthetics.

Methods: A retrospective analysis was performed on pre- and post-treatment diagnostic records of 29 patients with bimaxillary protrusion treated by extraction of four first premolars. Plaster models were scanned and STL files were analyzed digitally using Maestro software. The same models were assessed manually using a divider, scale, brass wire and scale. Maxillary and mandibular inter-canine width, inter-molar width and arch length were evaluated. Descriptive statistics and significance testing were performed with a significance threshold of $p < 0.05$.

Results: Digital measurements showed increases in maxillary and mandibular inter-canine width of 1.460 mm and 1.402 mm, respectively, while inter-molar width decreased by 2.850 mm in the maxilla and 2.170 mm in the mandible. Maxillary and mandibular arch length decreased by 14.738 mm and 11.961 mm, respectively. Manual measurements showed the same overall pattern. The study reported no significant differences between corresponding digital and manual measurements.

Conclusion: Following four first premolar extraction treatment, inter-canine width increased, inter-molar width decreased and arch length decreased in both arches. Digital and manual linear measurements were considered comparably reliable.

Keywords: Bimaxillary protrusion, STL files, Arch widths, Digital, Manual

1. Introduction

Bimaxillary protrusion and dental crowding represent common orthodontic treatment challenges. In patients with bimaxillary protrusion, extraction of four first premolars is frequently used to provide space for retraction of the maxillary and mandibular anterior teeth and to reduce dental proclination. Because arch form and arch width are relevant to smile esthetics, the effect of extraction treatment on transverse and sagittal arch dimensions remains clinically important.

In addition, Accurate assessment of dental arch dimensions is an essential component of orthodontic diagnosis, treatment planning, and evaluation of treatment outcomes. Measurements of inter-canine width, inter-molar width, and arch length obtained from dental models are routinely used to assess changes in arch form and dimensions following orthodontic treatment. Traditionally, these measurements have been performed manually on plaster models using instruments such as dividers, scales, and measuring wires. Although conventional model analysis is well established, manual measurements can be influenced by operator technique, landmark identification, accessibility of the measurement points, and the physical handling of dental casts.

The introduction of digital three-dimensional models has provided an alternative approach to conventional orthodontic model analysis. Digital models can be generated by scanning conventional plaster casts and subsequently analyzed using specialized software. In contrast to manual measurements, digital analysis allows measurements to be performed directly on three-dimensional representations of the dentition, with the potential advantages of easier data storage, retrieval, transfer, and repeated assessment. Digital models may also facilitate the identification of specific anatomical landmarks and measurement of complex arch dimensions without the physical limitations associated with plaster casts.

Direct comparison of digital and manual measurements performed on the same dental models can therefore provide a more meaningful assessment of the agreement between the two methods.

2. Aims & Objectives

Primary aim: To assess changes in arch length and arch width in bimaxillary protrusion cases treated with extraction of four first premolars.

Secondary aim: To determine potential deviation in arch width and arch length when measured digitally and manually.

3. Material and Methods

Study design and sample

This retrospective study analyzed pre- and post-treatment diagnostic records of 29 patients with bimaxillary protrusion. Eligible patients had been treated with extraction of four first premolars and had a full permanent dentition except for third molars. Dental casts were required to be properly fabricated and free of defects.

Exclusion criteria

The presentation excluded patients undergoing prosthetic rehabilitation and patients with congenital anomalies or congenitally missing teeth.

Model analysis

After application of the selection criteria, pre- and post-treatment plaster models were scanned and the resulting STL files were imported into Maestro software for digital analysis. Manual analysis was performed on the same sample.

Measurements

Inter-canine width was defined as the distance between the canine cusp tips on the right and left sides. Inter-molar width was measured between the mesiobuccal cusp tips of the right and left first molars. Arch length was defined as the total length of the arch formed from the mesial surface of the left first permanent molar to the mesial surface of the right first permanent molar along the automatically constructed arch curve.

For manual analysis, inter-canine and inter-molar widths were measured with a divider and scale, while arch length was measured using brass wire and a scale.

4. Statistical Analysis

Data were tabulated and evaluated for statistical significance. Descriptive statistics were used to calculate means and standard deviations. A p-value <0.05 was considered statistically significant.

5. Results

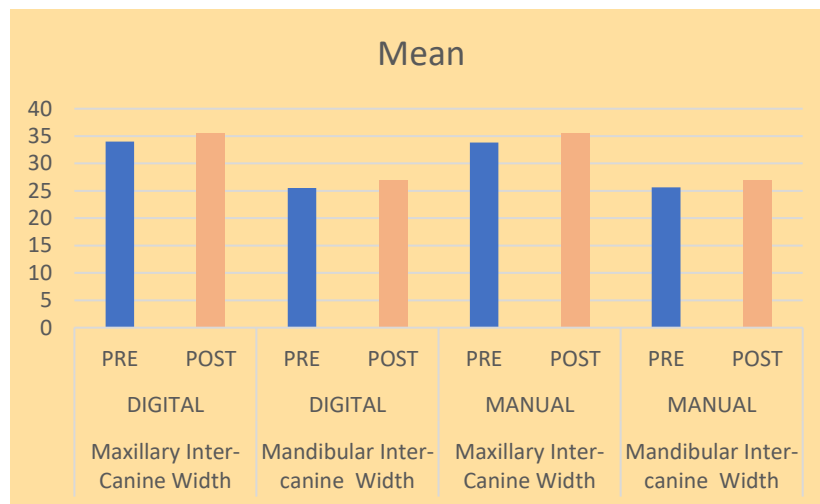
The principal numerical findings extracted from the presentation are summarized below. Positive change indicates an increase from pre-treatment to post-treatment, whereas negative change indicates a reduction.

Variable	Method	Pre (mm)	Post (mm)	Change (mm)	p-value
Maxillary inter-canine width	Digital	33.982	35.442	+1.460	0.009
Maxillary inter-canine width	Manual	33.828	35.483	+1.655	0.004
Mandibular inter-canine width	Digital	25.509	26.911	+1.402	0.005
Mandibular inter-canine width	Manual	25.621	26.931	+1.310	0.010
Maxillary inter-molar width	Digital	50.514	47.664	-2.850	0.000
Maxillary inter-molar width	Manual	49.931	47.793	-2.138	0.000
Mandibular inter-molar width	Digital	42.380	40.210	-2.170	0.000
Mandibular inter-molar width	Manual	42.207	40.345	-1.862	0.000
Maxillary arch length	Digital	79.503	64.765	-14.738	0.000
Maxillary arch length	Manual	78.897	64.276	-14.621	0.000

Variable	Method	Pre (mm)	Post (mm)	Change (mm)	p-value
Mandibular arch length	Digital	66.260	54.299	-11.961	0.000
Mandibular arch length	Manual	65.655	53.344	-12.311	0.000

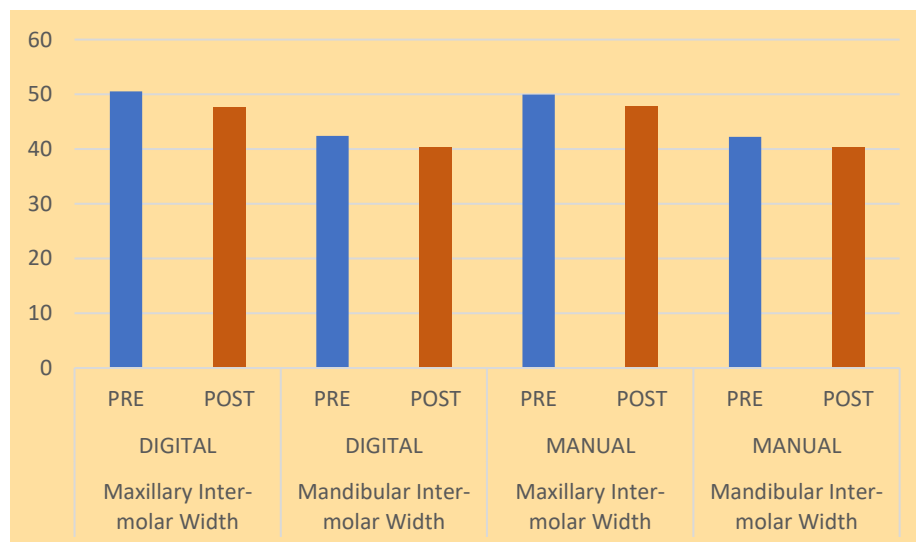
Inter-canine width

Digital analysis demonstrated a significant increase in maxillary inter-canine width from 33.982 to 35.442 mm (mean change +1.460 mm; $p=0.009$) and mandibular inter-canine width from 25.509 to 26.911 mm (mean change +1.402 mm; $p=0.005$). Manual analysis showed corresponding increases of 1.655 mm in the maxilla (33.828 to 35.483 mm; $p=0.004$) and 1.310 mm in the mandible (25.621 to 26.931 mm; $p=0.010$).



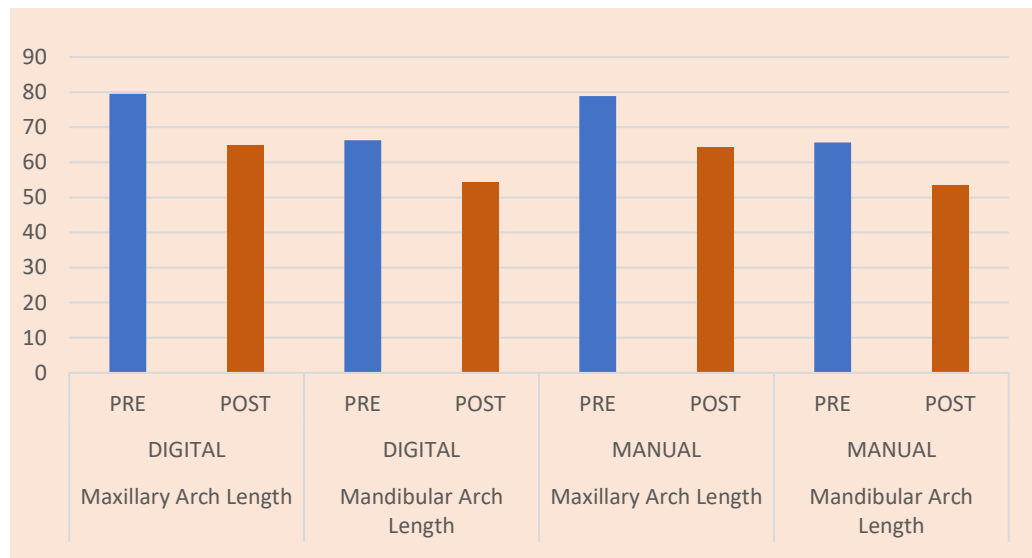
Inter-molar width

Digital analysis demonstrated reductions in inter-molar width of 2.850 mm in the maxilla (50.514 to 47.664 mm; $p<0.001$) and 2.170 mm in the mandible (42.380 to 40.210 mm; $p<0.001$). Manual measurements showed corresponding reductions of 2.138 mm in the maxilla and 1.862 mm in the mandible.



Arch length

Digital analysis demonstrated marked reductions in arch length of 14.738 mm in the maxilla (79.503 to 64.765 mm) and 11.961 mm in the mandible (66.260 to 54.299 mm), with the presentation reporting highly significant results ($p<0.001$). Manual measurements similarly demonstrated reductions of 14.621 mm in the maxilla and 12.311 mm in the mandible.



Digital versus manual assessment

The presentation reported that comparison of individual measurements between digital and manual analyses showed no significant difference in any group. Thus, the two approaches produced comparable linear measurements in this sample

Discussion

Stability has long been considered an important objective of orthodontic treatment, and preservation of arch dimensions has been discussed in relation to post-treatment stability. In bimaxillary protrusion, extraction of four first premolars facilitates anterior retraction and can consequently alter linear arch dimensions.

The present findings from the supplied presentation demonstrated an increase in inter-canine width together with a reduction in inter-molar width after extraction treatment. This pattern was reported as being in agreement with Cho et al. (2010). The observed decrease in maxillary and mandibular arch length was similarly described as consistent with Herzog et al. (2017).

An additional important finding was the agreement between digital and manual model measurements. The comparable values support the use of digital models as an alternative to conventional plaster models for linear orthodontic measurements in the context examined. The study relates this observation to previous literature, including the systematic review by Fleming et al., which concluded that digital models can be a reliable alternative for assessing arch length, arch width and crowding.

Conclusion

Maxillary and mandibular inter-canine widths increased following four first premolar extraction treatment.

Maxillary and mandibular inter-molar widths decreased following treatment.

Maxillary and mandibular arch lengths showed substantial and statistically significant reductions.

No significant difference was reported between corresponding manual and digital linear measurements.

Digital and manual methods can therefore be considered comparably reliable for the linear measurements evaluated in this study.

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