Serial Evaluation of Orthodontic Intrusion using Intraoral Scans : A Preliminary Study

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ABSTRACT:
Introduction : Study models are an essential component of diagnosis and treatment planning in orthodontics. In dentistry, a number of digital intraoral scanning systems, scanners, and configurations have been introduced and put into use. Among these, regular assessment of tooth movement is essential to achieve both functional and aesthetic outcomes and prevent unwarranted tooth movements. Hence this study was conducted to evaluate orthodontic intrusion using 3D intraoral scans at sequential intervals of time.
Materials and Methods : The subjects consisted of 10 patients who were about to start their orthodontic treatment using fixed orthodontic appliances. A TMA intrusion spring was placed such that the cantilever arm was resting on the occlusal surface of the premolar included in the study. This provided a force apically in the vertical direction. The 3shape ortho analyzer program was used to assess the tooth movements using digital models. By superimposing the scanned models of T0 and T3 of each patient, the overall extent of intrusion was determined. To compare the level of intrusion in the study group, a parametric Independent t-test was used.
Results : The mean distance between the standard occlusal plane and the premolar subjected to orthodontic intrusion was calculated. There was a statistically significant change (p=0.002) in the level of intrusion before treatment and after 12 weeks.
Conclusion : The study examined the use of intraoral scanners to monitor intricate orthodontic tooth movements in patients subjected to fixed appliance therapy. Intraoral scanners could provide valuable periodic assessments, potentially improving the overall quality and outcomes of orthodontic therapy.

1. Introduction

Study models are an essential component of diagnosis and treatment planning in orthodontics. Accurate intraoral structural impressions are used to produce these study models. The most common technique for taking traditional impressions is by the use of custom trays or elastomeric materials [1]. With the advent of computer-aided design and computer-aided production, orthodontic science has progressed and a variety of techniques have been introduced [2]. In dentistry, a number of digital intraoral scanning systems, scanners, and configurations have been introduced and put into use [3]. This facilitates the capture of optical impressions of tooth tissues and arches [4]. The use of digital scans and models in orthodontics is broad; it can improve a number of orthodontic operations in addition to streamlining diagnostic procedures and decision-making [5]. Methods such as individual tooth segmentation, evaluation, arch shape assessment, determination of crowding, spacing and other malocclusions is made possible [6]. Intraoral features such as overjet, overbite, transverse distances, and Bolton disparity can also be assessed. As a result, the operator is able to place brackets as well as apply indirect bonding in addition to presenting suggested treatment strategies and obtaining a virtual diagnostic setup [7]. Additionally, it can be used to further analyze a variety of procedures, such as the design and production of clear aligners, indirect bonding trays, orthodontic braces, surgical guides, or splints (made using 3D printed CAD-CAM technology), planning the locations of orthodontic mini-implants, localizing impacted canines, managing cases of cleft lip and palate, and even forecasting the results of orthognathic treatment after surgery [8,9,10].

Among these, regular assessment of tooth movement is essential to achieve both functional and aesthetic outcomes and prevent unwarranted tooth movements. Several researchers tried to evaluate the movement of teeth during orthodontic treatment by superimposing digital models created from dental casts. Very few studies have measured the amount of movement of teeth on a regular basis both during treatment with fixed orthodontic appliances and during retention following treatment [11,12,13,14]. This could be because it is challenging to take impressions without the teeth distorting when fixed appliances are affixed. Hence this study was conducted to evaluate orthodontic intrusion using 3D intraoral scans at sequential intervals of time.

2. MATERIALS AND METHODS:

Sample selection:

The present study was conducted after the approval by the Institutional review board of Saveetha Dental College and Hospitals, Chennai with the ethical approval number of :IHEC/SDC/ORTHO-2101/24/177 . The subjects consisted of 10 patients (6 males and 4 females) who were about to start their orthodontic treatment using fixed orthodontic appliances. All the patients who consented to participate in the trial had given their informed consent. The inclusion criteria included the intraoral scans of patients who were indicated for upper premolar intrusion as a part of the treatment plan. Exclusion criteria included patients with pre-existing orthodontic appliances, soft tissue lesions, missing teeth or other pathologies.

Orthodontic tooth movement:

A TMA intrusion spring was placed such that the cantilever arm was resting on the occlusal surface of the premolar included in the study. This provided a force apically in the vertical direction as mentioned previously by Mehta et. al (15). A 3-mm internal diameter coil was integrated in front of each molar using 0.017″ × 0.025″ TMA wire (Ormco, Orange, California) to prepare each spring (Figure 1). The premolar's occlusal surface has the spring connected to it. To strengthen the molar anchoring unit, the upper first molars had a trans palatal arch banded. The spring exerted an invasive force on the premolar upon activation.

Intraoral scanning:

Throughout the first three months of orthodontic therapy, the maxillary dentitions were scanned once a month: at T0, after 4 weeks, 8 weeks and 12 weeks into the treatment. Intraoral scans were taken using an intraoral digital scanner Trios (3Shape; Copenhagen, Denmark) following the recommendations listed by the manufacturer. During the procedure, the patients were instructed to rest on the dental chair tilted at 45-degrees angulation. Their cheeks were drawn back for scanning and moisture control, and air drying of the teeth were done. The occlusal surface, buccal and lingual surfaces, and the palatal areas of the teeth were scanned continually from one posterior side to the other.

Evaluation of orthodontic tooth movement:

The 3shape ortho analyzer program was used to assess the tooth movements using digital models. The intraoral scans were loaded in the software and digital models were created. These models were then assessed for the amount of intrusion using digital measurements. For periodic evaluation of the intrusive movement, occlusal plane of the model was taken as reference plane as shown in Figure 1. At periodic time intervals as mentioned previously, the distance between the premolar's buccal cusp tip and the occlusal plane derived 3 dimentionally was measured. The tooth position's linear changes were assessed using this technique. By superimposing the scanned models of T0 and T3 of each patient, the overall extent of intrusion was determined (Figure 2).

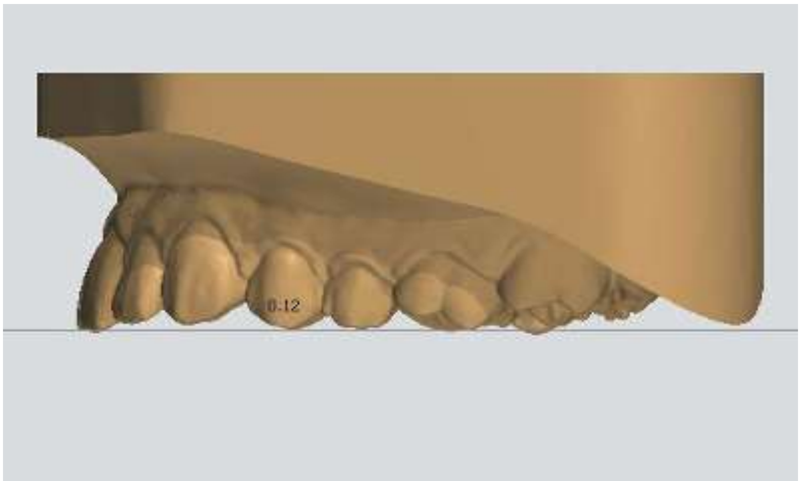

Figure 1: Digital measurement for the amount of intrusion from the occlusal plane.

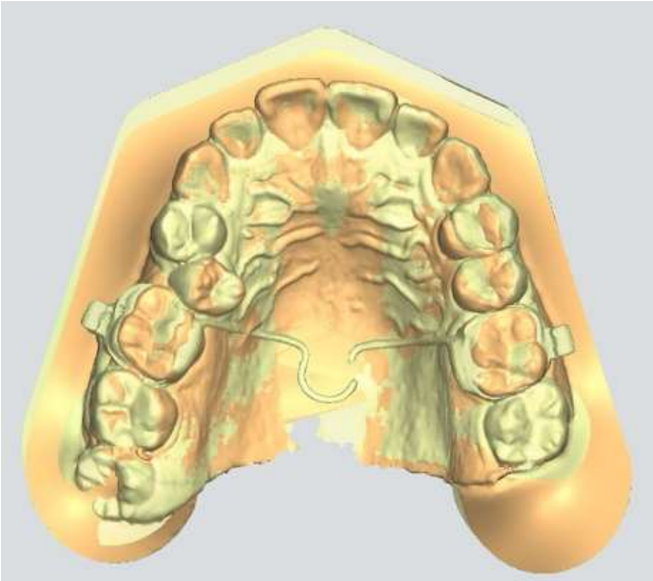

Figure 2: Digital Superimposition using Ortho analyser software.

Statistical Analysis:

SPSS (Version 23.0) was used to determine the statistical analysis. The numerical Shapiro-Wilk test was used to determine normality. A normal distribution of the data was discovered. Descriptive and analytical statistics were performed as needed. To compare the level of intrusion in the study group, a parametric Independent t-test was used. A statistically significant p-value of less than 0.05 was determined.

3. RESULTS :

After orthodontic intrusive forces were applied, the variation in the degree of intrusion was quantified and examined. The mean distance between the standard occlusal plane and the premolar subjected to orthodontic intrusion was calculated and represented in Table 1. There was a statistically significant change (p=0.002) in the level of intrusion before treatment and after 12 weeks.

Table 1: Amount of intrusion before and after treatment

STUDY GROUP (mean in mm)		P VALUE
AT T0 (Before intrusion)	AT T3 (after intrusion)	0.002*
0.433	0.999	

Level of significance $p<0.05$

4. DISCUSSION:

This study provided significant insight on the effectiveness of intrusion springs in causing these alterations and the usefulness of intraoral scanners for tracking orthodontic tooth movement. The results of the present study were similar to that of the findings derived by Caballero et al., who demonstrated that intrusion springs could effectively induce mandibular canine intrusion [16]. He observed that the mechanics predominantly affected the first molar, with minimal impact on posterior anchorage. This observation underscored the localized effect of intrusion springs, which is crucial for maintaining overall dental alignment during treatment. Similarly, Mehta et al. utilized a different approach involving an intrusion spring with a cantilever arm and a posterior coil. By applying a force of 50 grams, a notable active intrusion of premolars was achieved over a six-week period [15]. This method's success in achieving desired tooth movement highlighted the adaptability and effectiveness of intrusion springs in different clinical scenarios. Ghaleb et al. further supported the effectiveness of these devices by applying a continuous buccally directed force of 150 grams on maxillary first premolars using a segmental archwire. The significant buccal movement observed ($p < 0.05$) demonstrated the precision with which segmental archwires could influence tooth movement, particularly in terms of buccal direction [17].

Previous research also included the utilization of intraoral scans [18,19,20,21]. The advancement in digital technology has revolutionized orthodontic diagnostics, particularly through the use of intraoral scans [19,20]. Lee et al. provided evidence that significant vertical intrusion could be achieved with orthodontic forces over a three-month period. Although the study noted some buccal tipping, the use of intraoral scans allowed for detailed tracking of vertical movement, demonstrating the technology's capability in capturing intricate changes [22]. Ali et al. employed three-dimensional virtual models to assess tooth movement. The use of the best-fit method for superimposing models at pretreatment and post-treatment stages revealed statistically significant posterior movement of maxillary teeth [23]. This method, coupled with statistical analysis using paired t-tests, confirmed the reliability of intraoral scans in measuring orthodontic changes. Yun et al. used serial digital models with the palatal surface as a reference area, finding this method clinically acceptable for tracking minute orthodontic movements [11]. His method showed how intraoral scans could identify minute angular and linear changes in teeth, including those in I molars, canines and incisors, every month. The accuracy and reliability of this technology were highlighted by the low method errors and strong intraclass correlation coefficient.

The present study extended these findings by evaluating orthodontic intrusion of premolar teeth at multiple intervals: before treatment (T0), after 4 weeks (T1), 8 weeks (T2), and 12 weeks (T3). The significant changes in tooth position detected post-intrusion ($p = 0.002$) highlighted the efficiency of intraoral scanners in monitoring subtle orthodontic treatments. The ability to observe and measure these changes with high accuracy emphasized the role of intraoral scanners in optimizing orthodontic treatment planning and adjustment.

Limitations

While the study provides valuable insights, a few constraints including a comparatively limited sample size that can affect how broadly the findings could be applied. In some cases methodological errors in measuring tooth movement could have occurred, affecting the precision of the results.

Future Scope

Further investigations using intraoral scanners are required to evaluate the stability and long-term efficacy of orthodontic procedures thereby giving a more comprehensive view of treatment results. To improve tooth movement evaluations' accuracy, measurement methods should be improved and errors should be minimized.

5. CONCLUSION:

The study examined the use of intraoral scanners to monitor intricate orthodontic tooth movements in patients subjected to fixed appliance therapy. Orthodontists often find it challenging to detect minor movements during treatment, particularly when changes such as intrusion are very gradual. Accurate measurement and recognition of these subtle movements are essential for optimizing treatment. Intraoral scanners could provide valuable periodic assessments, potentially improving the overall quality and outcomes of orthodontic therapy.

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