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Artificial intelligence driven dental monitoring and surveillance of malocclusion treatment in orthodontic patients

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Abstract

Background: Orthodontic treatment success does not only depend on proper diagnosis and treatment, but also on patient's compliance. Patient's progress and compliance can be monitored through in-office visits at certain time intervals. However, this interval is not necessarily ideal for every patient.

Purpose: To overcome this limitation, Dental Monitoring® (DM) is introduced as artificial intelligence (AI) driven remote monitoring, which analyzes tooth movement, oral hygiene, and the condition of orthodontic appliances. This study aimed to describe the clinical application of DM based on the number of in-office visits, duration of treatment, number of refinements, stability of retention phase, tooth movement, patient's oral hygiene, and patient's subjective perception regarding DM.

Review: Based on five articles included, the use of DM during orthodontic treatment had several advantages including the increase of patient's compliance on maintaining oral hygiene and significant reduction of in-office visits, thus increasing the treatment's effectiveness and comfort for patients. Duration of treatment and number of refinements that do not differ significantly between DM and non-DM users are considered as DM's other advantages as it could reduce in-office visits without compromising treatment's effectiveness. Orthodontic relapse can also be identified hence severe relapse can be prevented.

Conclusion: The clinical application of DM can reduce in-office visits, improve oral hygiene and retention stability. However, the use of DM must be carefully considered to prevent decline in doctor-patient relationships.

Keywords: Dental Monitoring; Remote monitoring; Artificial intelligence; Orthodontics; Medicine

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1. Introduction

The success of orthodontic treatment does not only depend on proper diagnosis and treatment, but also on patient's compliance [1,2]. During orthodontic treatment, several studies have shown a rapid decline in the level of oral hygiene, which may lead to changes in composition of bacteria flora, leading to dental plaque accumulation. The presence of dental plaque for a critical length of time can cause demineralization, white spot lesions, and gingival inflammation. These conditions can negatively affect the clinical outcome of orthodontic treatment due to possible discontinuation of the treatment [3].

After orthodontic treatment, patient's compliance in using removable retainer is also needed. However, studies showed patient's compliance tends to decrease, resulting in orthodontic relapse, with the prevalence ranging from 10-67%. Therefore, dentists need to regularly monitor the adherence of patients in using their removable retainer [1].

Patient's progress and compliance can be monitored through in-office visits at certain time intervals. However, this interval is not necessarily ideal for every patient [4]. To overcome this limitation, Dental Monitoring® (DM, Dental Monitoring, Paris, France) is introduced as artificial intelligence (AI) driven remote monitoring, which analyzes tooth movement, oral hygiene, and the condition of orthodontic appliances [1,3,5].

DM consists of three integrated platforms: mobile application to take photos of the patient's intraoral condition; AI algorithm that detects tooth movement, level of oral hygiene, and the integrity of orthodontic appliances; and doctor-dashboard [6,7,8]. Dentists will be notified after the patient's intraoral photos have been analyzed by the AI algorithm. Dentists can also communicate with the patient through the application [4,9].

The use of DM in orthodontic treatment can potentially benefit both the dentists and the patient. Dentists can increase treatment efficiency and the patient can reduce the cost and time required to make in-person visit to the dentists' office [10]. In addition, remote areas with limited access to orthodontic treatment can benefit greatly from utilizing DM [11]. The purpose of this review is to describe the clinical application of DM based on the number of in-office visits, duration of treatment, number of refinements, stability of retention phase, tooth movement, patient's oral hygiene, and patient's subjective perception regarding DM.

2. Literature review

Based on five articles included, the use of DM during orthodontic treatment had several advantages including the increase of patient's compliance on maintaining oral hygiene and significant reduction of in-office visits, thus increasing the treatment's effectiveness and comfort for patients. Duration of treatment and number of refinements that do not differ significantly between DM and non-DM users are considered as DM's other advantages as it could reduce in-office visits without compromising treatment's effectiveness. Orthodontic relapse can also be identified by analyzing the movement of the teeth hence severe relapse can be prevented. Table 1 shows data extracted from 5 articles included in the review.

Table 1 Results and Conclusion of Included Articles

No	Parameter	References	Result
1	Number of in-office visits	[5]	The use of DM can significantly reduce in-office visits compared to the control group (7.56 vs 9.82; $P < 0.001$).
		[6]	The use of DM showed a 33.1% reduction in in-office visits or 3.5 less visits compared to the control group (7.12 vs 10.64; $P = 0.001$).
		[4]	The number of in-office visits in the DM users group is lower than that in the control group (3.07 vs 4.75), with a difference of 1.68 visits after 7 months of evaluation.
2	Treatment duration	[5]	The use of DM did not show a significant difference in treatment duration compared to the control group (14.58 vs 13.91).
		[6]	The use of DM did not show a significant reduction in treatment duration compared to the control group (12 months vs. 14 months).

3	Number of refinements	[5]	The use of DM did not show a significant difference in the number of refinements (1.00 vs. 0.79), total number of refinement aligners (19.91 vs. 19.85), and time to first refinement (9.46 vs. 9.97) compared to the group. control.
		[6]	The use of DM showed a reduction in the number of refinements (1.5 vs. 1.6) and time to first refinement (4.33 vs. 6.02; P = 0.001) which was not significant compared to the control group.
4	Retention stability	[1]	The use of DM showed a significant reduction in the incidence of removable retainer misfit compared to the control group (p = 0.027)
5	Tooth movement	[6]	Statistically, DM was able to predict tooth position more accurately (P<0.05) than the control group in maxillary anterior rotational movements (0.99°) and mandibular anterior buccolingual movements (0.06 mm). The difference in tooth movement between the two groups was not clinically significant (>0.5 mm or >2°). The DM user group achieved the same clinical accuracy as the control group in predicting tooth movement
6	Patient's oral hygiene	[3]	The use of DM showed a significant decrease in plaque index (PI) at the 3rd month (p = 0.010) and 4th month (p = 0.039) observation No carious lesions were found in the DM user group. In the control group that did not use DM, 5 caries lesion onset (CLO) were found (P = 0.049).
7	Patient's perspective towards DM	[5]	The results of the questionnaire showed that 44 out of 60 patients using DM (68.8%) felt that DM was "easy" or "very easy" to do. The results of the questionnaire showed that 46 of 56 (71.9%) patients using DM were "satisfied" or "very satisfied" in communicating with dentists using DM, with the average duration for which patients had to perform a scan was 5.16 ± 3.6 minutes. The results of the questionnaire showed that 56 out of 60 DM patients (88%) prefer to have minimal in-office visits. Overall, the average patient satisfaction with DM was 4.25 from a 5-point Likert scale. 12% of patients were not satisfied with the use of DM and prefer in-office visits
		[4]	1. DM users indicated the DM application was easy to use with 86% of patients indicating its use was "easy" or "very easy" with an average of 4.31 out of 5.0. The use of DM was considered beneficial in treatment with 84% of patients indicating its use was "useful" and "very useful" with an average of 4.4 out of 5.0 The most frequently mentioned benefit of patients using DM was "better communication" (mentioned by 47 patients), "increased comfort" (mentioned by 44 patients), and "decreased in-office visits" (mentioned by 40 patients) The most common problem experienced by DM users is "difficulty in performing scans" (mentioned by 27 patients)

3. Discussion

DM is an orthodontic application that can be used for remote monitoring. It combines teledentistry and artificial intelligence (AI) using a knowledge-based algorithm, allowing an accurate semi-automated monitoring of orthodontic

treatment [7]. Through DM, dentists can remotely monitor tooth movement, orthodontic devices integrity, and patient's oral hygiene [8].

Based on the five journals included in this review, the clinical application of DM can provide several advantages for its users, including facilitating dentists to monitor patients' tooth movements remotely and reducing the number of in-office visits. In addition, the use of DM can also increase patient compliance in maintaining oral hygiene and using retainers [1,3-6].

The clinical application and performance of DM in monitoring tooth movement was investigated by Hansa et al.4 Study by Hansa et al. showed no clinically significant difference in achieving ideal tooth movement between the DM and control groups [4]. Statistically, significant differences in tooth movement between the DM user group and the control group were only shown through three parameters: maxillary anterior rotational movements, mandibular anterior buccolingual movements, and maxillary posterior dentition tip [4].

Reduction of in-office visits with the use of DM could benefit both dentists and patients. Dentists can improve their clinic efficiency, while for patients, DM can increase time effectiveness and patient comfort, as well as reduce travel costs for in-office visits [4,5]. Furthermore, the decrease in the number of in-office visits with the use of DM did not compromise treatment's effectiveness. This was proven by the duration of treatment and the number of refinements which did not differ significantly between the DM user group and the control group [5,6].

DM can also increase patient compliance in maintaining oral hygiene because DM can monitor various indicators of poor oral hygiene (such as gingivitis, inadequate cleaning of orthodontic devices, caries, calculus) and send warning notifications to patients and dentists to improve patient's oral hygiene [11]. Research conducted by Sangalli et al. proved that DM is effective in reducing plaque index (PI) in orthodontic patients [1]. There was no caries detected in the DM user group, while in the control group there were five carious lesion onsets (CLOs). This might be due to the increase in patient's compliance in maintaining oral hygiene. However, the improvement in oral hygiene in the DM user group might also be due to the Hawthorne effect, in which the patient changed his behavior because the patient was aware that they were under observation [3].

Besides being used during the treatment period, DM can also be used in post-treatment to monitor retention stability. Every patient is expected to wear a removable retainer every night and attend regular in-office visits, especially during the first 6 months after the active orthodontic appliance has been removed. The use of DM in the retention phase can increase patient compliance in using removable retainers and reducing the incidence of misfit retainers. In addition, DM can also identify orthodontic relapse earlier so that dentists can determine further actions to prevent more severe orthodontic relapse. However, the positive effects of DM reported in the study might also be due to the Hawthorne effect [1].

Apart from the various advantages of DM, the use of DM also has some disadvantages. In a study conducted by Hansa, Seeman & Vaid, 12% of patients were dissatisfied with the use of DM and preferred in-office visits [5]. This is supported by the study of Hansa et al. which showed that 27 patients mentioned having difficulty scanning with DM [11]. This may be influenced by manual skills and the patient's proficiency in using technology. Patients who are more adept at using technology will find it easier to use DM, and vice versa [4,5]. In addition, each patient also has different mouth opening ability and masticatory muscles tonicity. This can affect the visibility of the teeth in the oral cavity when taking intra oral pictures with DM. Therefore, preferences in using DM or making routine in-office visits depend on each patient [3].

4. Conclusion

Based on the review, it can be concluded that the main advantage of using DM is reducing the number of in-office visits which can increase efficiency and convenience for both dentists and patients. Further studies should be conducted using randomized control trials with placebo groups to eliminate possible confounding factors and Hawthorne effect.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare there is no conflict of interest in this study.

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