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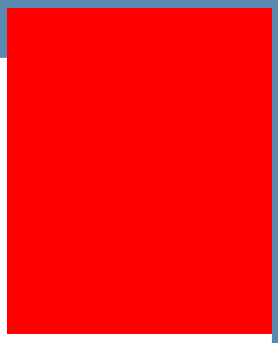
Interest of clear aligners plus low-frequency vibration in a mix of 66 cases



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Key words *accelerated osteogenic orthodontics, AcceleDent Optima, clear aligners, Invisalign system, orthodontic aligners, vibration*

Objectives: *The main goal of the present study was to find whether the use of nearly invisible aligners together with vibratory stimulation was able to shorten the lag times between aligner exchanges, reduce the number of refinements and thus reduce the total treatment time.*

Materials and methods: *The study included 66 successive participants who gave agreement to specific treatment protocols. Each treatment included the use of aligners for durations shorter than those recommended by the manufacturer together with daily vibratory stimulation. The purpose of the analysis was to search for the: i) number of aligners used; ii) number of refinements required; iii) duration of aligner wear; iv) total treatment durations.*

Results: *The protocols resulted in: i) a reduction of the expected number of refinements (less than two in 51 cases); ii) a reduction of the expected durations of aligner wear; iii) mostly, 60%, 44% and 20% reduction of the total treatment durations with initially scheduled at 14-, 10-, and 7-day intervals, respectively; which corresponded to median gains of 14, 7, and 2 months over the expected total treatment durations ($P < 0.001$).*

Conclusion: *The combination of nearly invisible aligners with vibration was able to shorten the lag times between visits. This was likely to have alleviated the workload of dental clinics per patient and increased patient satisfaction, at least in the total treatment duration.*

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Introduction

Orthodontics have lately seen great progress[1] such as adult orthodontic treatment techniques, (clear) aligners, accelerated treatments with corticotomy or other surgical interventions, and, more recently, the use of low-frequency vibration to accelerate tooth movement[2-4].

Today, accelerating tooth movement may be obtained by one of the following three procedures: i) corticotomy or piezocision[5], which are surgical techniques that recruit cells through mechanical stress or inflammatory reactions, however, the active phase should not exceed 12 weeks (14 weeks in specific cases)[5] and the dental arch and/or aligner ex-

changes (at 10-day interval visits) may be painful; ii) laser beams, electrical stimuli or vitamin D injections, which are procedures able to recruit osteoblast precursor cells[6-8]; iii) mechanical vibration or administration of parathyroid hormone comprise procedures that help the recruitment of osteoclasts[2,9,10].

Initially, mechanical stimulation through vibration was introduced in 1985 to heal fractures and treat osteoporosis[11]. The effect of vibration on accelerating bone-remodelling processes has been first reported by Kopher et al[12,13]. Its aim was to modulate the growth of intrasutural bone in patients suffering from craniofacial anomalies through vibratory stimulation of osteoblasts and osteoclasts. Also, vibrations would stimulate the secretion of cytokines, including macrophage colony-stimulating factor (M-CSF)[14,15] and increase directly or indirectly the receptor activator of nuclear factor-kappa-B ligand/osteoprotegerin (RANKL/OPG) ratio[16].

The specialised literature on vibration in orthodontics is still relatively limited; a search via PubMed (in October 2019; using the keywords: orthodontic treatment, accelerated orthodontics, vibration) resulted in 35 articles. Of these, seven were only descriptive or used inappropriate devices (toothbrushes)[17-23], 18 reported significant results[3,11,24-39], five hardly had significant results[40-44], and five had non-significant results[2,9,45-47]. Thus, the issue of whether vibrations speed up orthodontic treatment does not have yet a definitive answer.

Within this context, we found it interesting to investigate 66 cases treated with clear aligners plus low-frequency vibration to check whether this combination was able to reduce the number of refinements and shorten the whole treatment duration.

Materials and methods

Study background

This historical cohort study was conducted in a private orthodontics clinic. It included only adults whose first visit took place between 16 December 2015 and 3 December 2018 and who had to undertake a teeth alignment treatment. All included patients gave their informed consent to the proposed orthodontic management protocol regarding all stages and procedures, including the use of specific alignment and vibration devices.

Participants and data

The study used for analysis data relative to the first 66 patients who agreed to the study protocol, procedures and devices. The participants' characteristics collected for this study were: age, sex, type of malocclusion (skeletal vs dental), dental crowding measurement, dental procedures (need for extraction or not, need for surgery or not), alignment treatment option (Full vs Lite), and initial number of aligners.

Devices

The dental procedures for all patients included Invisalign for teeth alignment and AcceleDent for vibratory stimulation. An Invisalign (Align Technology, San Jose, CA, USA) device consists in a series of nearly invisible aligners designed to straighten the teeth during an orthodontic treatment. It may be used instead of metal wires and brackets and has the main advantages of being custom-made and removable (up to 4 hours daily). AcceleDent OptimaTM (OrthoAccel Technologies, Houston, TX, USA) is a non-invasive vibratory device that produces painless micropulsations able to stimulate cellular activity, speed up teeth movement, increase the rate of bone remodelling and reduce the discomfort linked with braces or aligners wear[31,35]. This device accelerates orthodontic treatment, providing a daily regular use (20 minutes a day).

Procedures

The frequency at which the aligners were exchanged varied according to the clinical presentation of each participant, the status of initial malocclusion and the stages of the treatment.

All participants carried first a series of nearly 12 aligners for 1 week each. The duration of aligner wear was readapted (mostly reduced) at the second visit.

In simple cases, the frequency of aligner exchange was 3 to 5 days. This frequency was established according to the patient availability for visits, the presence of discomfort or pain, the indications of ClinCheck software and to the clinic's timetable. Anyway, no frequency was less than 3 days.

In complex occlusion cases (need for extractions or lacking teeth; among 35 cases) and in cases of important distalisation with Class II mechanics, the participant had weekly aligner exchanges. In these cases, aligner exchanges without AcceleDent seemed insufficient and unable to provide

satisfactory results; the patients underwent aligner exchanges at 14-day intervals.

Radiographic checks were also adapted to each case according to the estimated total duration of the treatment. An orthopantomogram was carried out at mid-treatment whenever there was no risk of root resorption at the final check-up. In presence of such a risk, the orthopantomogram was made at the quarter (1/4) of the treatment period.

The study evaluated mainly the percentage of treatment time gained with the use of AcceleDent relative to the expected treatment time according to conventional treatments with the same number of aligners (7, 10, or 14 days per aligner, according to the manufacturer's instructions).

Whenever convenient results were not obtained at the end of each refinement, a new dental digital impression was used to establish a new ClinCheck-aided treatment plan. In such cases, the patients were given a set of five passive aligners, the treatment was considered momentarily stopped, and the waiting time was subtracted from the total treatment duration.

The study evaluated also the total number of aligner refinements, the number of aligners per refinement and the mean duration of aligner wear per patient.

Statistical analysis

Quantitative data were described using the median and the quartiles of their distributions. Qualitative data were described using the frequencies and their proportions per category. The analyses were carried out with R software. The level of statistical significance was set at 0.05.

Table 1 Characteristics of the 66 participants

Characteristic		Value*
Age		32 (27.25; 41)
Women		44 (66.7%)
Skeletal class	1	28 (42.4%)
	2	37 (56.1%)
	3	1 (1.5%)
Vertical pattern	Hypodivergent	39 (59.1%)
	Normodivergent	14 (21.2%)
	Hyperdivergent	13 (19.7%)
Transverse pattern	Maxillary endognathy	10 (15.2%)
Molar class	1	35 (53%)
	2	28 (42.4%)
	3	3 (4.5%)
Canine class	1	31 (47%)
	2	34 (51.5%)
	3	1 (1.5%)
Dental crowding		–2.00 (–3; –2)
Need for extraction		2 (3%)
Need for surgery		5 (7.6%)
Invisalign option	Lite	6 (9.1%)
	Full	60 (90.9%)

*Median (first quartile; third quartile) or frequency (percentage).

Results

The characteristics of the 66 participants are shown in Table 1. The study sample was considered quite representative of the clinic's clients. The majority of the participants had skeletal Class I or II (98.5%), molar class I or II (95.4%) and canine class I or II (98.5%). Only two participants needed extraction and only five needed surgery.

The Invisalign option 'Full' was advised by the dental surgeon to 60 participants (90.9%). The median initial number of aligners was 34.5 (Q1; Q3: 19; 41). The median duration of treatment with AcceleDent was 9 months (6.2; 12.28).

The median of the percentage of decrease in total treatment duration with theoretical 14-day lags between aligners was 60.2% (55; 63.7); this was equivalent to a 14-month median decrease in total treatment duration ($P < 0.001$).

The median of the percentage of decrease in total treatment duration with theoretical 10-day lags between aligners was 44.3% (37; 49.2); this was equivalent to a 7.3-month median decrease in total treatment duration ($P < 0.001$).

The median of the percentage of decrease in total treatment duration with theoretical 7-day lags between aligners

was 20.4% (9.9; 27.4), which was equivalent to 2.2-month median decrease in total treatment duration ($P < 0.001$).

The management of the 66 cases required 76 refinements; that was, on average, 1.15 refinements per participant. Precisely, 11 cases (16.7%) did not require refinement, 40 (60.6%) required one refinement, and 15 (22.7%) required more than one refinement. The median number of aligners per refinement was 16 (11.25; 25.00) and the median number of aligners per patient over the whole treatment duration was 52.5 (34.25; 65.5).

The median mean duration of aligner wear per participant was 5.6 days (5.1; 6.3).

Discussion

The present study yielded some positive interesting results on the use of aligners + vibration; mainly, shortening the intervals between visits and decreasing the number of refinements. Comparing the present results with previous ones was not an easy task. Actually, a review of the specialised literature on clear aligner + vibration treatment retrieved few studies that reported disparate results because of very distinct clinical and technical research settings. Nevertheless, the present results agree with those of recent trials conducted by Shipley[18] and Shipley et al[40] regarding the reduction of the number of aligners required, the average time for aligner change (3.5-day gain), the number of refinements needed, and the total treatment time. However, results from other trials did not show significant differences regarding completion rates[26], initial tooth movement rates[48] and total treatment time[48] or found no advantage of using vibration in initial alignments[49].

Within this context, one may notice that two reviews published in 2015[21] and 2017[43] left the issue open to further study. The former: i) could not assess treatment duration or number of visits; ii) reported reduction of irregularity in the mandibular incisor region and higher rate of maxillary canine distalisation; but, iii) considered the quality of evidence poor and the results "clinically unimportant". The latter reported: i) negative results regarding the rate of tooth movement; ii) positive but weak evidence regarding accelerating canine retraction; but, iii) no advantage for alignment.

All things considered, recent results of aligner + vibration are more encouraging than older ones, but strong and highly significant evidence is still lacking.

One feature of the present study is the inclusion of patients who agreed to use AcceleDent in the hope of shortening the treatment duration and cutting its costs. Another interesting feature was a relative sample homogeneity obtained through the limitation of the number of complex cases (distalisation, space closure, tooth axis correction or complicated supraclusion) in 7- and 10-day interval aligner exchanges. The presence of complex cases would have increased the number of aligners. Unfortunately, most previous studies have reported mean results without accurate information on case complexities, which complicates study comparisons.

The study showed that the time gain in total treatment duration with 7-day exchanges was underestimated because, without AcceleDent, complex cases require > 7-day intervals. In our current practice, complex cases are put on 10- or 14-day interval aligner exchanges.

The study carried out comparisons between recommended and actual frequencies of clear aligner exchanges assuming the use of the same number of aligners per patient. As the number of aligners was generally reduced, the present study might have underestimated the total time reductions with use of AcceleDent.

One interesting result was the reduction of the number of refinements. Actually, in the present study, there were 11 cases without refinement (16.7%) and 51 cases with 0 or 1 refinement (77.3%), which represents a median of 1.15 refinement per case. This was very interesting because it reduced the workload of the clinic that obviously depends on the number of aligners and refinements.

One limitation of the present study was the difficulty of determining the main factor responsible for the observed time gain: use of AcceleDent or improvement of alignment technique. In our opinion, this gain resulted from combining the two factors but a clearer image should be obtained with a comparative study with controls. Given that the wide heterogeneity of the patient clinical characteristics made it very difficult to match a treatment and a control group, only a randomised clinical trial would be able to clarify the issue.

Conclusions

The present study demonstrated that the use of Invisalign + AcceleDent was able to reduce significantly treatment durations by 20 to 60% vs 7 to 14 standard lag times between aligner exchanges and also reduced the number of expected refinements per treatments (77% did not require more than one refinement). From our experience, we believe the median mean duration of aligner wear per participant (here, 5.6 days) may be further shortened. Indeed, our clinic used to shorten 7-day lags to 5-, 4- or 3-day lags according to various criteria; it has now planned to shift to 3-day lags in most cases. This will motivate another specific report.

Declaration

The authors declare that they have no conflicts of interest.

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