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CASE REPORT

Management of mandibular incisors crowding by using passive lower lingual holding arch: a case series and literature review

Ahlam Habib[1], Ahmed Ghoneima[1], Samira Diar-Bakirly[1,*]

[1] Department of Orthodontics and pediatric Dentistry, Hamdan Bin Mohammed College of Dental Medicine, Mohammed Bin Rashid University of Medicine and Health Science (MBRU), 505055 Dubai, UAE

***Correspondence**
Samira.diarbakirly@mbru.ac.ae
(Samira Diar-Bakirly)

Abstract

Mandibular incisor crowding is a frequently encountered problem in daily orthodontic treatment. Success of the treatment greatly depends on the orthodontist's ability to manage the factors contributing to the existing crowding and implementing the proper interceptive means. The passive lower lingual holding arch (LLHA) helps maintain the position of the permanent first molars after the exfoliation of primary molars and canines. Thus, relieving the mandibular incisor crowding during transitional dentition. Four case reports age ranged from 11–13.5 years old were used to report the effect of using LLHA on mandibular incisor crowding. Little's Irregularity Index (LII) was used to assess the severity of mandibular incisors crowding as well as to compare the severity of the crowding before and after the use of LLHA. Passive LLHA could be considered the appliance of choice for space maintenance during the mixed dentition. Mandibular incisor crowding was reduced as measured by LII after the use of the passive LLHA over a duration of twenty months.

Keywords

Mandibular incisors crowding; Mixed dentition; Lower lingual arch; Little's index

1. Introduction

Mixed dentition stage starts from the first permanent tooth eruption at around six years of age until the last deciduous tooth exfoliation at around thirteen years of age. Several changes play a part to accommodate the transition from primary to permanent dentition. Arch length increase which occurs only until the eruption of permanent canines is one of these changes. It is caused partially by the proclination of the permanent incisors and increase of the inter-canine width and inter-molar width [1–4]. Another factor that contributes to permanent teeth accommodation into the arch is the mesiodistal width change between the deciduous molars and canines with their successors represented in Leeway space and E-space [3–9]. It is crucial to note that as patients grow into their adolescent years, subsequent arch length reduction takes place. Late mesial shift into the E-space to adjust the molar relation and the further uprighting of the permanent incisors to adjust the overjet and overbite explains this arch length reduction and thus potential mandibular incisor crowding [1–9].

According to the National Health and Nutrition Examination Survey (NHANES III, 1998), dental crowding can be considered the most common form of malocclusion among children in the United States. The prevalence of dental crowding has been reported to be nearly 50% with varying degrees of severity of overlap between the anterior teeth [10]. Dental crowding is categorized into three types [11]; primary crowding occurs because of incompatibility between the primary teeth dimension and the permanent successor and it is considered genetic. Secondary crowding occurs in the posterior dentition due to early extraction of the primary molars with consequent arch length loss. Tertiary crowding, which is evident at the end of the growth spurt of the mandible and coincides with the eruption of the third molars. Primary crowding is additionally subdivided into two groups: definitive and temporary [12]. It has been reported that 89%–94.7% of patients who had crowding in the mixed dentition stage and/or early loss of primary canine also showed crowding in the permanent dentition stage [2, 7, 13, 14]. Several methods have been used to assess the mandibular incisor crowding. Little's Irregularity Index (LII) being one of the methods, was developed in 1975 by Robert Little and is a diagnostic index that is used to assess relapse, irregularity, and alignment of mandibular incisors [13].

Baume in 1950 and McDonald in 1987 have shown that without space maintenance, the arch perimeter is reduced after deciduous tooth loss during transition from mixed to permanent dentition [15, 16]. Although plaque accumulation is one of the disadvantages of space maintainers, yet patients should be encouraged to maintain adequate oral hygiene while having the device [6]. Once the space maintainer is fitted, it must be followed up by regular checks to guarantee that the appliance is intact and to monitor the permanent dentition's development and eruption. It is imperative to note that the lack of space for permanent teeth is an indication of space regaining rather than maintenance. Adequate assessment of space analysis is thus required to determine the right interceptive means and decide if the patient needs a specialist [6].

Various types of space maintainers, either fixed or removable [6, 17], each with various indications, have been used and reported in the literature. Appliances such as the Mayes Fixed Crozat (Frozat) [18], the Crozat appliance (Bihelix and Quadhelix), the Wilson lingual arch [19, 20], the lip bumper [20, 21] have been used in the mandibular arch as variations of space maintainer devices. Appliances in the maxillary arch such as the cervical headgear have been used and led to spontaneous expansion and increase in the mandibular arch length, thus, possibly relieving crowding [22]. The passive LLHA has been long used as a space maintainer to preserve arch length [4, 23–25]. LLHA is made either of 1.25 mm or 0.9 mm stainless steel wire and can be inserted into the sheaths of the molars (removable), or either welded/soldered to molar bands or bonded directly to the lingual surface of mandibular molars [26, 27]. Using a 1.25 mm wire compared to a 0.9 mm wire will increase wire stiffness which will result in increased forces on the mandibular incisors and first molars [26, 28]. Earlier in the 20th century, Mershon explained that an active form of LLHA could be used, stabilized on the molars by attaching a small spring to the main arch to allow tooth movement when activated and produce transversal widening [29].

In this article, four cases are presented to show the effectiveness of the lower lingual holding arch in minimizing/resolving mandibular anterior crowding.

2. Case reports

2.1 Patient information

Accompanied by their parents/guardians, four adolescent Caucasian patients age ranged from 11–13.5 years old (1 boy and 3 girls) were examined with no specific concerns about their family's medical and dental histories. The patients' medical history was negative for systemic conditions or allergies with no history of previous orthodontic treatment.

2.2 Clinical findings

For all the four patients, comprehensive orthodontic screening has been conducted including extraoral and intraoral examination reported in each case. Intraoral examination revealed mixed dentition stage with mandibular incisor crowding and healthy periodontium with minor plaque accumulation. All permanent mandibular incisors were present as well as at least retained bilateral primary second molars.

2.3 Timeline

The treatment duration for all patients was twenty months after cementing the passive LLHA. Patients were kept under observation until complete permanent dentition erupted, without any further active orthodontic treatment. Deciduous teeth exfoliated in a normal sequential manner.

2.4 Diagnostic assessment

Each patient's dental cast models (pre-treatment and post-treatment) were scanned using Ortho Insight IT 3D Laser Scanner (Motionview Software, LLC, Hixson, TN, USA) with the cast positioned in a coronal position and calibrated to zero rotation. STL files of the scanned models were then uploaded to 2010 Dolphin Imaging & Management Solutions (@petterson technology) and crowding was then assessed using Little's irregularity index method. The horizontal distance between the incisor edges was measured in mm using the software's digital ruler. The measured values were added, and LII was calculated for every patient, pre-treatment and post-treatment values were then compared. Intraoral photos were taken as well at the pre-treatment and post-treatment stages.

2.5 Therapeutic intervention

A passive LLHA was constructed for every patient using 0.036 inch stainless steel wire (0.9 Chromium, Scheu Dental Anchor. Iserlon city, Germany, 2020) to preserve the leeway space. The space maintainer was soldered to the mandibular first molar bands (Maximum Retention™ Bands, American Orthodontics Inc. Sheboygan, WI, USA, 2022). The molar bands of the LLHA were then cemented over the first permanent molars.

2.6 Follow-up and outcomes

The patients were followed up during the treatment period of over twenty months. The appliance was regularly checked every three months to ensure there is no damage to the appliance and to enhance the patients' oral hygiene regime. Exfoliation pattern of primary teeth and the permanent dentition's development and eruption was observed at each visit as well. Improvement or resolution of mandibular incisors crowding after cementation of passive LLHA was noted in all four cases. The difference between pre-treatment and post-treatment values of LII for all patients ranged between 4.9 mm to 7.7 mm. (Table 1)

2.6.1 Case 1

An 11-year-old girl with skeletal class I relation and dental class I molar malocclusion/severe maxillary crowding and impacted maxillary canines. Intraoral examination revealed retained mandibular primary canines, primary first molars, and primary second molars. The mandibular incisor crowding was assessed, and her pre-treatment LII was 9.5 mm. After the use of the passive LLHA, post-treatment LII was 1.8 mm, the pre-treatment mandibular incisor crowding was almost resolved (Fig. 1A–D), (Table 1).

2.6.2 Case 2

A 12-years boy with skeletal class I relation and dental class I malocclusion. Intraoral examination revealed retained mandibular primary canines, primary first molars, and primary second molars. The mandibular incisor crowding was assessed and her pre-treatment LII was 9 mm. After the use of the passive LLHA, post-treatment LII was 3.2 mm, the initial mandibular incisor crowding was dramatically improved. (Fig. 2A–D), (Table 1).

TABLE 1. Descriptive data showing LII pre and post treatment values after twenty months of use of passive LLHA.

Case No.	Patient Age/Sex	Retained Primary Tooth	Pre-ttt LII	Post-ttt LII	Difference pre-ttt/post-ttt LII
Case 1	11 Years/Female	Canines, 1st molars, and 2nd molars	9.5 mm	1.8 mm	7.7 mm
Case 2	12 Years/Male	Canines, 1st molars, and 2nd molars	9.0 mm	3.2 mm	5.8 mm
Case 3	13.5 Years/Female	2nd molars	8.0 mm	1.0 mm	7.0 mm
Case 4	11 Years/Female	2nd molars	9.9 mm	5.0 mm	4.9 mm

LII: Little's Irregularity Index.

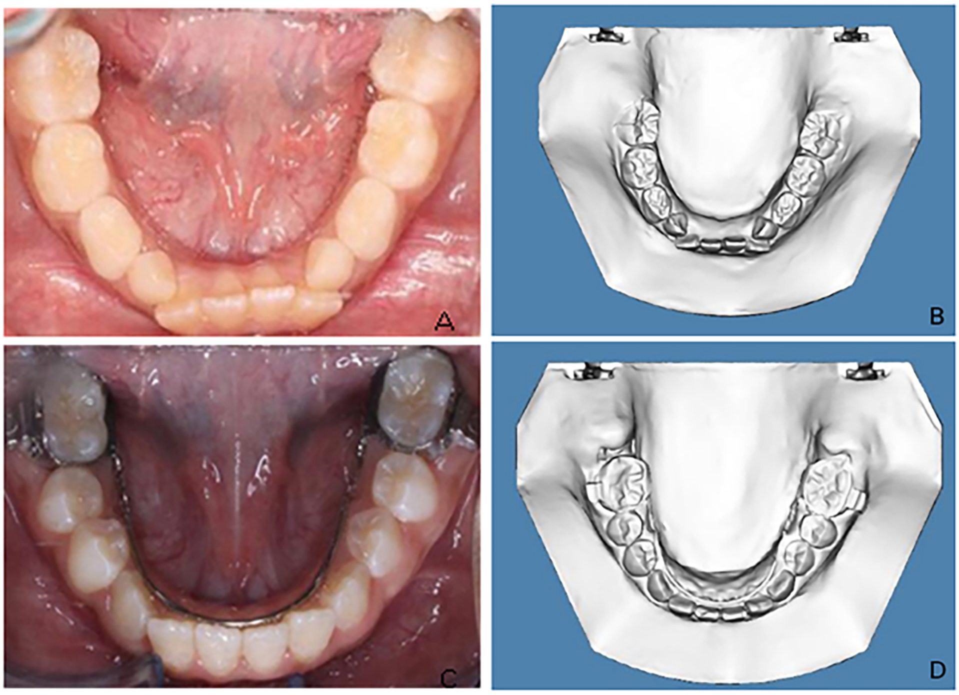

FIGURE 1. Case 1. (A) Intraoral pre-treatment photograph of mandibular arch. (B) Pre-treatment digital study cast displaying the mandibular incisor crowding. (C) Intraoral post-treatment photograph of mandibular arch. (D) Post-treatment digital study cast with LLHA.

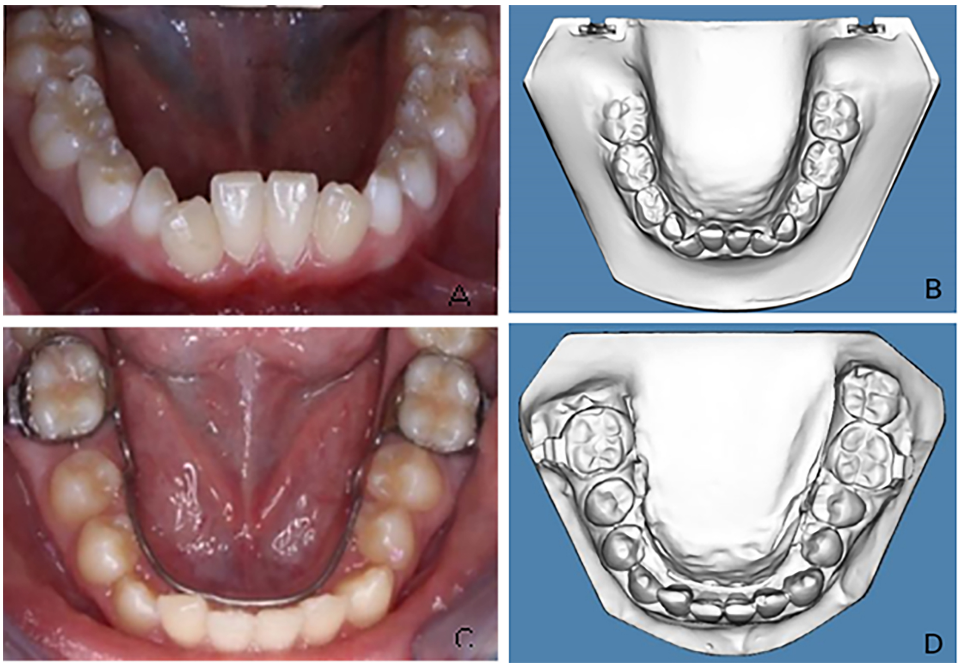

FIGURE 2. Case 2. (A) Intraoral pre-treatment photograph of mandibular arch. (B) Pre-treatment digital study cast displaying the mandibular incisor crowding. (C) Intraoral post-treatment photograph of mandibular arch. (D) Post-treatment digital study cast with LLHA.

2.6.3 Case 3

A 13 years and 5 months girl with skeletal class I relation and dental class I malocclusion. Intraoral examination revealed retained mandibular primary second molars. The mandibular incisor crowding was assessed, and her pre-treatment LII was 8 mm. After the use of the passive LLHA, post-treatment LII was 1 mm, the considerable change in LLI can be noted (Fig. 3A–D), (Table 1).

2.6.4 Case 4

An 11-year girl with skeletal class I relation and dental class I malocclusion. Her intra-oral examination revealed retained mandibular primary second molars. The mandibular incisor crowding was assessed, and her pretreatment LII was 9.9 mm. After the use of the passive LLHA, post-treatment LII was 5 mm with residual minor crowding of mandibular incisors remaining as shown (Fig. 4A–D), (Table 1).

3. Discussion

In this study, passive LLHA was used to relieve crowding in the mandibular incisors. The crowding was measured before and after the use of LLHA using the digital models of four patients and LII. The reliability/accuracy of LII using digital models to report different degrees of mandibular dental crowding has been investigated and validated by Palazzo *et al.* (2019) [30]. Accordingly, each patient's pre-treatment and post-treatment dental casts were scanned and used to report the cases.

All the patients included in this study presented with class I skeletal relation and did not need any orthopaedic treatment intervention. All the patients had at least one retained primary canines, primary first molars, and/or primary second molars. The treatment duration lasted twenty months, which is close to what has been reported in previous studies to resolve mandibular incisor crowding using a passive fixed lower lingual holding arch [23, 31].

Upon dealing with mandibular incisor crowding, the clinician needs to differentiate between temporary primary crowding that might be resolved spontaneously due to the dimensional changes that take place during mixed dentition and the definitive primary crowding that is related to the dental arch morphology and needs early intervention [12]. Mandibular incisors crowding is typical in mixed dentition as the width of the permanent incisors is 5 mm more than the primary incisors in the mandibular arch [5]. Identifying potential mandibular incisor crowding in permanent dentition can be observed by the lack of interdental space in primary dentition and premature loss of one of the primary canines [7]. Whether it was after the loss of primary canines and/or primary first or second molars, the use of passive LLHA as a simple interceptive treatment during the mixed dentition phase could lead to relief of mandibular incisor crowding in 15% of cases and an improvement in 49% [3].

In cases 1 and 2, the LLHA was placed when the bilateral primary canines, primary first molars, and primary second molars were not exfoliated yet. In cases 3 and 4, the LLHA was placed when the mandibular primary second molars bilaterally were the only retained primary teeth. Even preserving the second primary molars alone could contribute to the relief of the crowding by the space they provide after placement of LLHA before their exfoliation. In the present cases in this study, the average resolution of mandibular incisor crowding after placement of LLHA ranged from 4.9–7.7 mm. Mandibular incisor crowding resolution after placement of LLHA was reported in the literature to range between 5–10 mm [31].

Reduction in the mesial migration of the permanent mandibular first molars into the E space has been deemed one of the reasons behind the effects of the LLHA [6, 25, 31]. In 1995, Gianelly demonstrated that a lingual arch can be used to maintain arch length by preventing the mesial movement of the molars and the lingual collapse of the mandibular incisors [24]. In addition, preserving the leeway space of canine and primary molars allows the distal drifting of mandibular canines and first premolars into the available leeway space [24–26, 31]. It is imperative to note that this distal shift of the canines can lead to a greater inter-canine distance rather than a true arch expansion. Gianelly and Brennan *et al.* [23] (2000) noted an increase of the intercanine width when using LLHA by 1.5 mm. In 1995, Chiarini and DeBaets [32] noted that an increase of the intercanine width by 1.1 mm because of the lateral drifting of canines was due to their migration to the leeway space. In an observational cohort study an increase in intercanine and intermolar width was reported to be 0.72 mm and 2.41 mm respectively [9]. Nevertheless, an Increase in arch length could vary from as little as 0.2 mm due to distal movement of the molars after 0.9 mm SS lingual arch insertion to as much as 4.8 mm [4].

It is not prudent to claim that resolving mandibular incisor crowding could be achieved by holding the mandibular permanent molars from drifting mesially and allowing the distal drift of permanent canines, only. Proclination of the mandibular incisors was reported as another possible reason behind the relief of crowding as well [26, 33]. Rebellato *et al.* [25] (1997) confirmed that the lingual arch reduced arch perimeter loss at the expense of mandibular incisor proclination. Forward movement and proclination of the mandibular incisors relative to the A-Pog line (Li-A-Pog) was increased along the use of LLHA [26]. Yet, mandibular permanent incisors didn't always procline along the use of the LLHA. Lingual inclination of the mandibular permanent incisors rather than proclination has been reported in several studies [34–36].

Regardless of the different reasons behind the relief of mandibular incisor crowding, the agreed notion is that whenever the LLHA is used, it proves to be an effective appliance for preserving arch length [34]. LLHA simplicity in intervention is considered one of the main strengths of its use. The simplicity that resides in the design and fabrication of LLHA turns it to serve other goals beside space maintenance. Pontics added to lingual arches can serve in cases of missing teeth [37]. Moreover, incorporating an anterior biteplate in the appliance serve as anterior bite planes in deep bite cases when used in the upper arch [37].

Several limitations in this case series study such as the lack of classification of molar occlusion and incisor relation could be addressed in a future randomized clinical trial. Moreover, measuring the incisal inclination as well as the mesial movement of the permanent molars will reinforce the interpretation of the reasons behind the contributing factors that led to the

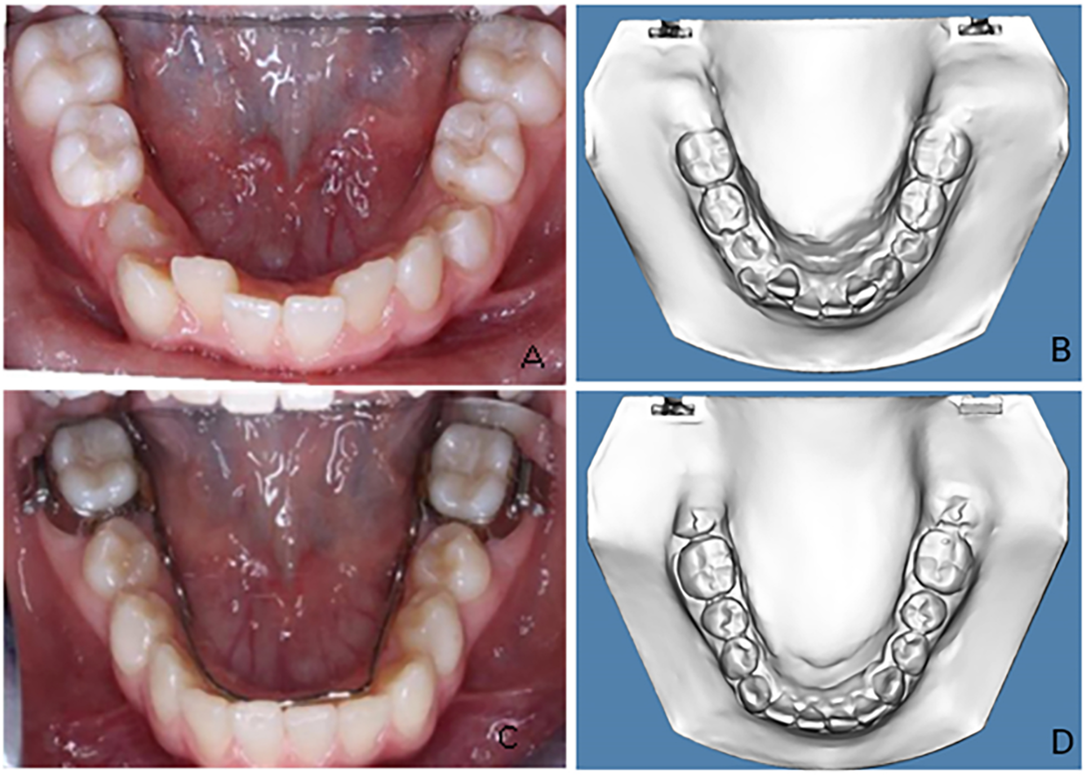

FIGURE 3. Case 3. (A) Intraoral pre-treatment photograph of mandibular arch. (B) Pre-treatment digital study cast displaying the mandibular incisor crowding. (C) Intraoral post-treatment photograph of mandibular arch. (D) Post-treatment digital study cast immediately after removal of the LLHA.

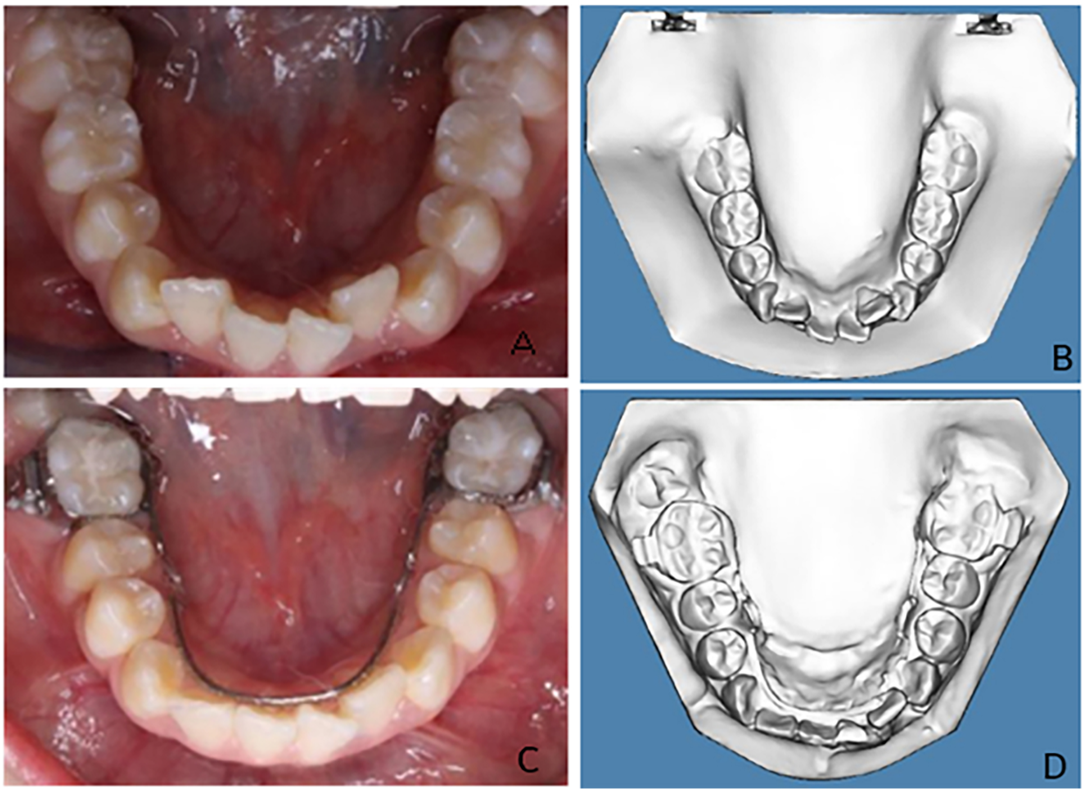

FIGURE 4. Case 4. (A) Intraoral pre-treatment photograph of mandibular arch. (B) Pre-treatment digital study cast displaying the mandibular incisor crowding. (C) Intraoral post-treatment photograph of mandibular arch. (D) Post-treatment digital study cast with LLHA.

relief of crowding. In addition, adding a matched control group, where no intervention was used, could be considered. However, diagnosing mandibular incisor crowding without intervention might be ethically challenging. Furthermore, measuring the changes in the intermolar width and inter canine width would be an added value in interpreting the effect of dimensional arch changes during the transition from primary to permanent dentition.

4. Conclusion

Utilizing interceptive treatment to avoid unnecessary loss of arch length has several benefits. Fewer complications, affordability in comparison to later treatment, and guidance of the developing dentitions favours the use of space maintainers as an interceptive treatment modality [17]. Passive lower lingual holding arch is considered the appliance of choice as an interceptive measure that provides space maintenance during the transitional dentition stage. Moreover, it could minimize and resolve mandibular incisor crowding by proper utilization of the leeway space in the mandibular arch in addition to the suggested effects on the permanent molars' mesial drift and mandibular incisor proclination. Taking advantage of this simple intervention device would unburden the space requirements of planned future orthodontic treatment characterized by crowded mandibular arches.

AVAILABILITY OF DATA AND MATERIALS

The data are contained within this article.

AUTHOR CONTRIBUTIONS

SDB, AH—designed the research study. AH—performed the research. SDB, AH and AG—analyzed the data. AH and SDB—wrote the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study (Protocol number IRB-2022-153) was reviewed and approved by the Institutional Review Board of Mohammed Bin Rashid University of Medicine and Health Sciences. The case report study was conducted using the University's dental hospital patients. Consent forms were obtained from all patients/guardians before initiating the patient's treatment.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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