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Novel Unilateral Dental Expander Appliance (UDEX): A Compound Innovative Materials

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Abstract: True unilateral posterior crossbite in adults is a challenging malocclusion to treat, especially when we need to correct cross-arch segments with unwanted effects on non-cross segments. Conventional expansion methods are expected to have some shortcomings; the Unilateral dental expander appliance used to restore unilateral cross bite dental arch is an uncommon appliance; for this, a designed new device is needed. This paper aimed to invite a new unilateral dental expander appliance (UDEX) to treat unilateral dental posterior crossbite in adults using available dental material, easy to use and handle, well tolerated by the patient, and biocompatible with oral structure. It could find that in all dental markets and dental clinics—an eighteen-year-old female with bilateral crossbite and upper and lower dental arch crowding. During active orthodontic treatment, a quad-helix expander had broken from one side at soldering between band and wire attachment. The patient did not show up to the clinic for a while due to COVID 19 pandemic lockdown, leading to a true unilateral crossbite at the dental arch's upper left side, especially at the molar premolars area. This unilateral cross bite was treated using a new specially designed expanded appliance as a unilateral posterior cross bite dental maxillary expander. As a result of this study, orthodontic treatment was finished within (15) months, much less than expected. We obtained Class I molar and canine relationships with uncrossed dental arches in both upper arch sides, proper overbite and overjet with well-leveled and aligned teeth as it confirmed by clinical examination and radiographic images (OPG (Orthopantomogram) and cephalometric radiograph (WebCeph analysis digitalized computer program). Conclude from that, the newly designed unilateral dental expander (UDEX) is proven to be useful for treating real unilateral posterior crossbites as single molar or premolar tooth and multiple joint unilateral crossed posterior teeth. Also, it could easily modify it for future unilateral crossed purposes. This appliance was fabricated using readily available dental

material, well tolerated by patients, and reduced the need for excessive patient compliance. An orthodontist could fabricate devices, or cautious laboratory work is required; it can rapidly achieve favorable results.

Keywords: Unilateral crossbite; dental material; acrylic pads; wire bending; expander

1 Introduction

Crossbite is a form of malocclusion where a tooth (or teeth) has a more buccal or lingual position (that is, the tooth is closer to the cheek or the tongue) than its corresponding antagonist tooth, the upper or lower dental arch. Posterior crossbite, which could be caused by skeletal, dental, or functional reasons, is one of the most common craniofacial disorders in transversal direction [1].

Unilateral posterior crossbite is either functional or true unilateral posterior crossbite [2]. Unilateral posterior crossbite is a specific subdivision of this disorder specified by an arch deficiency. It may change the growing subjects' mandibular growth pattern and form asymmetric condylar height, resulting in facial asymmetry [3]. Unilateral posterior crossbite is not an uncommon malocclusion encountered in daily orthodontic practice. Several studies reported a prevalence that varied between 8% and 23% [4–6]. Posterior crossbite etiology includes genetics, environmental and functional factors, and habits resulting from dental tipping, a skeletal deficiency, or a cleft palate. In a functional posterior crossbite, the presence of an occlusal interference causes a shift of the mandible upon closure [7–10].

However, early orthodontic treatment is controversial due to its cost-to-benefit ratio. Studies have reported that 50% of the crossbite cases treated in the primary dentition had to retreat in the early or late mixed dentition [8–11]. Early treatment has been recommended in crossbite cases because spontaneous correction is unusual [11–13].

There are many ways to treat posterior crossbite correction regarding the causative factors, including maxillary arch expansion, removal of occlusal interferences, and elimination of functional shift. Early cross bite corrections lead to a stable and normal occlusion pattern and contribute to symmetrical condylar growth, harmonious TMJ movements, and overall growth in the mandible [14,15]. In true unilateral posterior crossbite, the aim should be to move selected teeth on the maxillary arch's constricted side. If conventional appliances used to treat unilateral posterior crossbite, the maxillary dental arch would be expanded bilaterally, resulting in undesirable overexpansion of the unaffected side. Treatment of unilateral crossbite was performed by either slow palatal or rapid maxillary expansion, generally resulting in an unwanted overdevelopment of the side with normal pretreatment transversal relation with the mandibular teeth [16]. Therefore, it should increase the average side anchorage performance by suggesting cross elastics to the patient to overcome this problem [17]. There are many orthodontic bilateral expanders, but unfortunately, few studies are seeking unilateral dental expansion unless using more invasive methods of absolute skeletal anchorage, expansive unavailable materials, or need special laboratory equipment. This study designed a novel unilateral posterior dental maxillary expander appliance to correct true unilateral dental posterior cross bite without unwanted effect on the non-crossed side of the maxillary dental arch, from most available material in all dental clinic (cold cure acrylic resin (polymethyl methacrylate) and stainless steel (0.036-inch wire), orthodontic premolars and molars stainless steel bands).

1.1 Treatment Objectives

- To correct posterior crossbite via unilateral dental expander appliance (UDEX).
- To resolve upper and lower dental crowding and correct midline deviation.
- To achieve functional occlusion with maximum intercuspation, normal overbite, and overjet.

1.2 Alternative Approach

A simple way to treat a true unilateral posterior crossbite is to use a removable appliance incorporated with finger springs. This type of treatment approach might be preferred when the posterior crossbite is unilateral and involves one tooth. Alternatively, a removable appliance with a jackscrew sectioned asymmetrically could be used [18,19]. Sometimes, molars' clinical crowns' low height makes retention difficult and lessens the sufficient force necessary to produce maxillary expansion [20].

Unfortunately, any removable appliance leaves the clinician dependent on patient cooperation and presents hygiene problems. Elastics can be attached from the buccal attachments of the maxillary teeth to the lingual attachments of the mandibular teeth. This is an appropriate treatment approach only when the mandibular teeth have erupted with buccal inclination [21]. Otherwise, a mandibular lingual arch must be inserted to avoid lingual tipping and constriction of the mandibular arch. Like removable appliances, elastics require patient compliance and might extrude the involved teeth with the force's vertical component [22,23].

This extrusion effect is undesirable in vertical growers and patients with little overbite. An alternative treatment for a true unilateral posterior crossbite is to use fixed lingual maxillary expansion appliances.

W-arches and quad-helix appliances can be modified by changing the arms' length to include more teeth in the anchorage unit [24]. Fixed lingual arches have proven to require less overall treatment time and cost-effectiveness compared with removable appliances [25]. A modified quad-helix appliance has been designed to produce asymmetrical expansion [26]. However, its effectiveness has been presented in case reports; evidence-based research has not been evaluated; an asymmetrical maxillary expansion (AMEX) appliance was made of a 0.036-in diameter stainless steel wire be used as an alternative way for treatment of unilateral posterior cross bite.

2 Material and Methods

2.1 Appliance Fabrication

An impression was taken using alginate impression material (Irreversible hydrocolloid impression material, Major, Italy) with preformed stainless-steel bands (Dentaurum, Germany), cast was poured with dental stone (Calcined gypsum, DantiAnn stone, hard, Korea). The fitted stainless-steel bands were checked on the cast model that was brought down to the height of marginal ridges of the teeth and fixed with soft wax (a mixture of beeswax, paraffin waxes, and resins or other additive ingredients). A (Z) like shape 0.032 inch round Stainless-Steel wire has been fabricated, as shown in Fig. 1a, and fixed on dental stone cast using dental plaster of parries (Beta form of calcium sulfate hemihydrate ($CaSO4{\cdot}1/2H2O$) white gold, Korea), preparing for soldering process with the bands. This fabricated wire consists of two sides (Active or crossbite side and anchorage or non-crossbite side), active or crossbite side consists of two parts, two coil part (for increasing the flexibility of the wire to giving light continues force) and arm-band parts soldered to 1st Premolar and molar bands on the unilateral cross-side of upper arch using conventional brazing soldering technique (Two cobalt-chromium alloys (Blue Elgiloy, Crozat) and an austenitic

stainless-steel alloy (Remanium) were soldered by an electrochemically generated hydrogen-oxygen flame forming an overlapped joint design. For characterization of the soldered joint testing procedures included microhardness tests, metallographic examination, tension-shear tests, and surface analysis of the fractured joints by scanning electron microscopy. For any given soldering technique with an overlapped joint design, the correct joint length is determined by the ratio $t/s = 3$ (t = overlapped length; s = diameter of the smaller wire) [27], the bands help in controlling unwanted flaring effect on teeth during expansion, as showing in Fig. 1b, this part of appliance consider as active part that used to correct the unilateral cross bite. Anchorage side consists of zigzag shape wire part (used to increase the acrylic pad's retention that covered zigzag wire by orthodontic cold-cure acrylic resin (Methyl methacrylate, the polymerization of which is induced by chemical activation only, has been identified by varied terminology. The term "autopolymer" is a misnomer, since any polymerization is an automatic phenomenon, which occurs spontaneously under certain conditions, Orthocryl, Dentaurum, Germany) [28] using Sprinkle Technique leaving about 2 mm space between wire and cast to let the acrylic covered all around the wire, as shown in Fig. 1e and arm-band part soldered to 1st Premolar and molar bands on the non-crossed side of upper dental arch using conventional brazing soldering technique, this part of expander considers as anchorage part that received the support from the teeth and hard palate. After completing the fabrication process, the appliance was finished and polished very well using a carbide acrylic bur in the lathe, remove any acrylic flash and bulk, and place a small black bristle brush polishing lathe at low speed. Place pumice and disinfectant into pan. Using a generous amount of pumice, polish the stippled areas; place a large black bristle brush in the polishing lathe at high speed. Wet a rag wheel designated for use with pumice. At high speed with generous amounts of pumice, Polish all polishing appliance acrylic pad areas. As shown in Fig. 1c.

2.2 Case Presentation

An eighteen years old female attended a clinic for an orthodontic consultation. Medical and dental history had been taken and showed no abnormality or diseases. Extraoral examination shows normal symmetrical facial form with well facial proportion and straight profile; intraoral examination shows moderate crowding in upper and mild crowding in the lower arch with normal overjet and overbite, except for bilateral crossbite on upper arch at Premolar and molar area. In compliance with radiation protection criteria, especially for growing individuals, panoramic and cephalometric evaluations (using WebCeph analysis digitalized computer program) showed no orthodontic or skeletal problems, Fig. 2a. The treatment focused on the resolution of bilateral dental crossbite and dental crowding. During treatment, a significant problem was the quid helix appliance was broken (between solder and bands) from the left side, and the patient could not come to the clinic due to COVID 19 pandemic lockdown. She returned after two months, unilateral cross bite at the left side of the dental arch has been developed at 1st molar and premolars.

At that time, orthodontists were forced to develop an idea to solve this unilateral cross bite. During that period, the patient had maintained good oral hygiene according to orthodontists' recommendations. Otherwise, it would be easy for food or other debris to be stuck within the attachment resulting in malodor, inflammation, or infection.

Treatment started after scaling and polishing the teeth using non-fluoridated pumice; an active Quad-Helix appliance was inserted with Roth type brackets (slot 0.022 inch, Discovery, Dentaurum, Germany) with 0.014-inch Nickel-titanium (NITI) archwire (Dentaurum, Germany) as shown in Fig. 2b. Expansion with leveling and alignment provides many advantages as they

reduce treatment time, provide more control expansion with less flaring dental effect, and better retention at the end of expansion as the archwire keeps the final shape of the arch with or without the expander. At one point in time, a patient came to the clinic with a broken quid-helix, as mentioned previously.

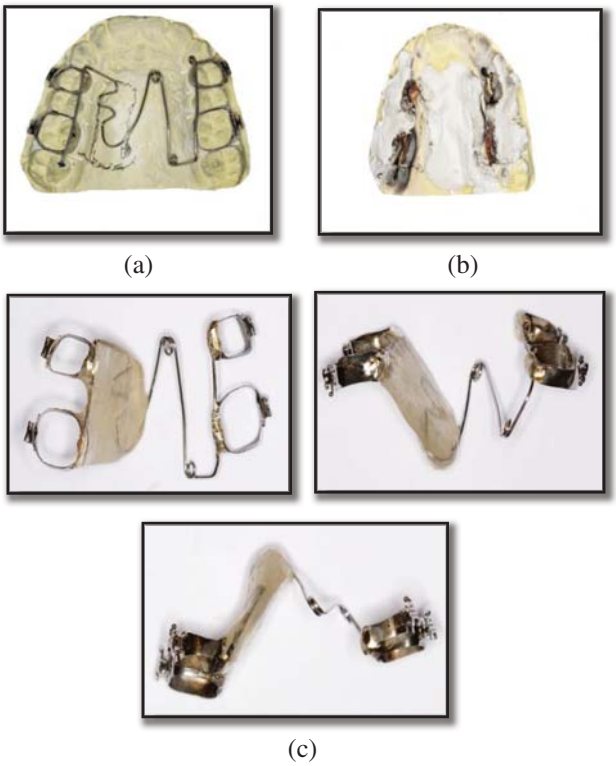


Figure 1: Fabrication steps of unilateral dental palatal expander (UDEX). (a) Cast with bands and Z-like shape wire; (b) soldering technique; (c) final appliance

The newly designed unilateral dental expander (UDEX) idea came at that time to fix this problem as the patient had unilateral posterior crossbite at the broken side (left side) of the dental arch and non-cross posterior teeth at the other side (right side) of the dental arch. This appliance provides unilateral expansion without effect on the non-cross side of the dental arch. Regarding the biomechanics, a single force is directed through the center of resistance (*C*rs). The tooth feels a tendency to translate or displace as all tooth points feel the same amount in the same direction of the applied force. Commonly, a single point force cannot be applied to act directly through (*C*rs) and must be used at the bracket. When a force does not act through (*C*rs) of a tooth, the tooth rotates. The rotational tendency, or moment, produced by force not working through (*C*rs) is expressed as the force's moment (*M*). The magnitude of (*M*) is measured as the magnitude of the force (F) multiplied by the perpendicular distance (d) between the line of the force and (*C*rs) ($M = F * d$) [29]. An activated unilateral dental, palatal expander was inserted (activation by withdrawing the active side using thumb and index fingers till the band's palatal aspect came in front of the buccal aspect of premolars and molar teeth and reactivated every three months). Fixation of the bands on upper 1st premolars and molars was performed using glass ionomer

cement (this helped control rotation and unwanted extrusion effect during active expansion) (GC, Japan) inactive status shown in Fig. 2b.

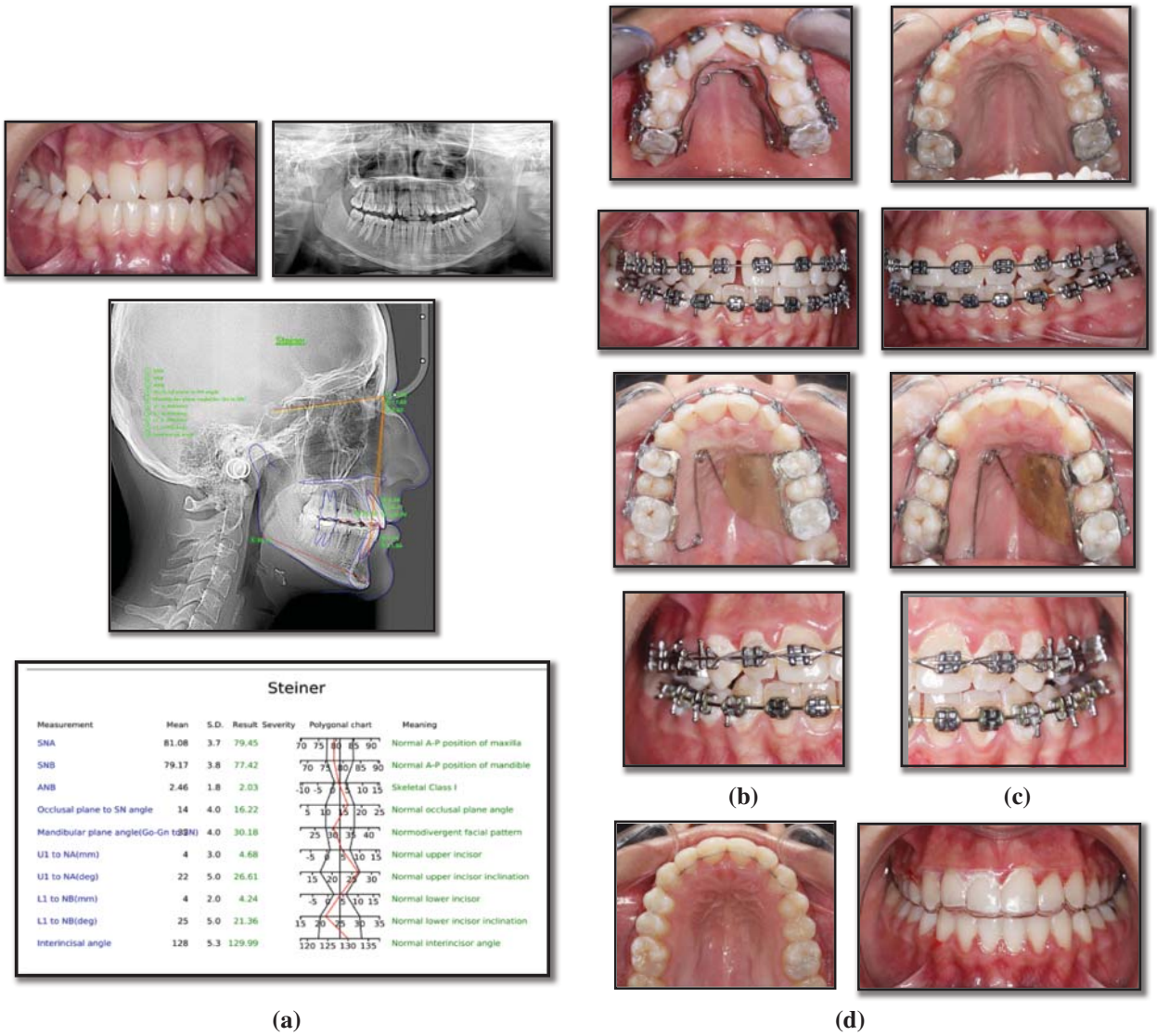


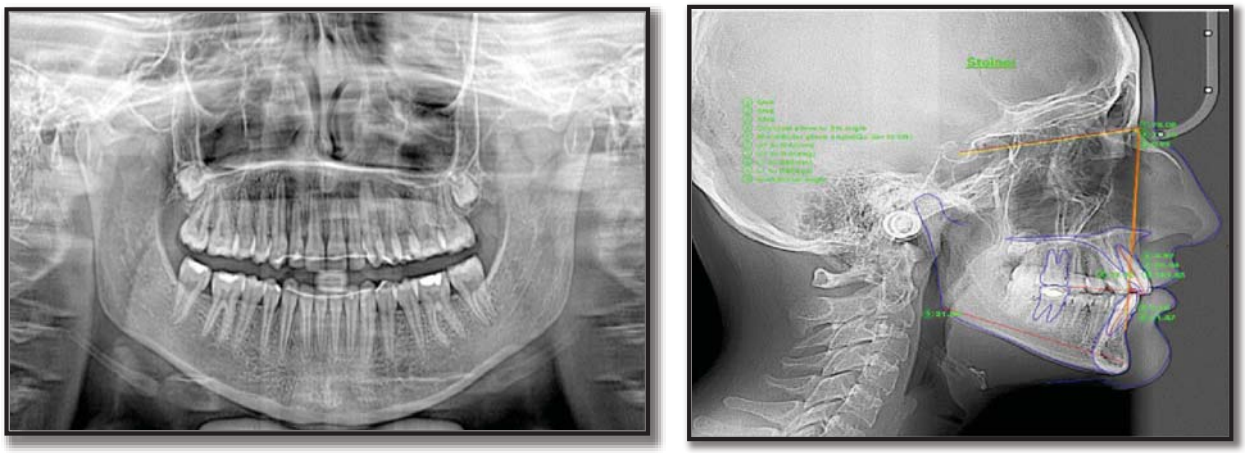
Figure 2: Treatment progress using: (a) Intraoral images with OPG and cephalometric radiography; (b) quad-helix appliance; (c) (UDEX) appliance progression; (d) final result and permanent and VFR retainer

The expansion process was controlled by exerting the calculated expansion amount on both sides using Vernier Caliper to measure the distance from central fossa of Premolar, molar to mid palatine raphe at each side (active side and anchorage side) after correcting the unilateral crossbite (activated two times and left for retention for two months). The case was finished with normal arch form, CI I molars and canine relationship, overjet, overbite, and coincide midline.

Brackets were deboned after 15 months of active treatment. Teeth well cleaned from remaining adhesive using finished carbide bure and fluoridated pumice for both arches. Fixed bonded retainer was fixed for both arches, extended from upper left to right canine for both arches, and VFR retainer (Vacuum formed retainer, polypropylene or polyvinylchloride (PVC) material) for upper arch only. The retention period was sustained for at least two years for bonded fixed retainer and six months full time, and another six months partial time for VFR retainer.

3 Results

The unilateral dental expander appliance was generally well tolerated by the patients. Orthodontic treatment lasted for (15) months (much less than usually expected). Obtained Class I molar and canine relationships in both sides along with uncrossed dental arches, normal overbite, and overjet with well leveled and aligned teeth with maximum intercuspation as it confirmed by clinical results and radiographic OPG (Orthopantomogram, cephalometric radiograph) analyzed used WebCeph digitalizing computerized program) images, as shown in Fig. 3. The patient exhibited more expansion on the unilateral cross bite side than on the anchorage side.



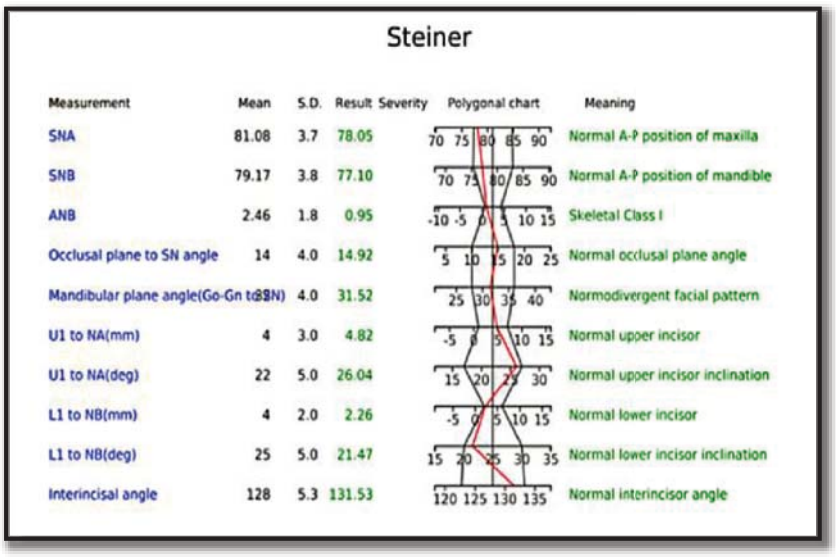


Figure 3: Radiographic final results (OPG and cephalometric)

This expansion could be verified by observing or photographically method that includes seeing the original midlines of the upper and lower arches and posterior teeth buccolingual relation with the antagonistic teeth, as shown in Fig. 4.

Figure 4: Photographical method for verification of (UDEX) appliance expansion accuracy

Also, using dental cast analysis method, that measured inter-maxillary premolars and molar width on the dental cast and compared the expansion amount at crossed and non-crossed side of upper maxillary arch from mid-palatal raphe (MPR) to the cusp tips (CT) of premolars and molars using Vernier Caliper (from MPR to right side (CT) of premolars and molars (non-crossed side), and from left MPR to right side (CT) of premolars and molars (crossed side) in Fig. 5. The measured amount of expansion from both sides of the maxillary dental arch to mid-palatal raphe are compared before and after use of (UDEX) appliance. This study shows well expansion in crossed side as it increases about 2.5 mm at the 1st Premolar, 2.4 mm at the 2nd Premolar, and 3.5 mm at the molar. In non-crossed sideshow neglected unwanted movement. As shown in the Tab. 1.

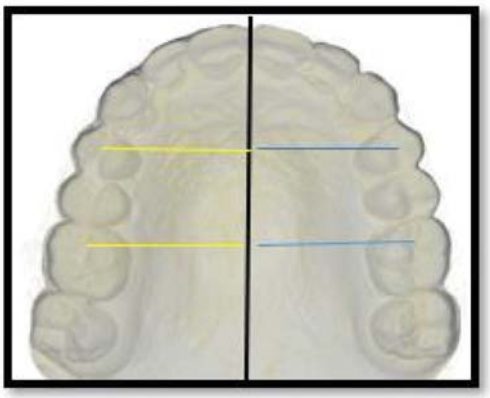


Figure 5: Dental cast analysis method shown final result after (UDEX) appliance application
*Black line (midline or MRF), blue line (distance from MRF to CF on non-crossed side), yellow line (distance from MRF to CF on crossed side)

Table 1: Arch measurement before and after expansion. *MPR (Mid-palatal raphe) CT (Cusp tips)

Arch width	Before expansion		After expansion	
	Right (MPR)-(CT) (non-crossed side) (mm)	Left (MPR)-(CT) (crossed side) (mm)	Right (MPR)-(CT) (non-crossed side) (mm)	Left (MPR)-(CT) (crossed side) (mm)
(4–4) premolar	14.3	14.3	14.4	16.7
(5–5) premolar	17.1	17.1	17.2	19.5
(6–6) molar	20.3	20.3	20.4	23.8

4 Discussion

The unilateral posterior cross bites can be detected by careful diagnosis. Also, knowledge of the treatment variables and their results is essential in successful orthodontic treatment. The selection of the appliance and its method of use are also important. This study evaluated the effects of the new unilateral dental expander (UDEX) in treating true unilateral posterior cross bite.

The purpose of this appliance is to achieve differential expansion just in the cross side without effect on the non-crossed side of the maxillary dental arch by exerting light and continuous force [30]. This appliance was designed to reinforce the anchorage of the non-cross bite side teeth by including an acrylic pad to receive more anchorage from the hard palate in addition to the dental anchorage. It is known that light and continuous force produces better physiologic adaptation, more excellent stability, and less relapse potential than other forces [30,31].

Dental Materials, the science that deals with the materials used in dentistry, their physical, mechanical & chemical properties, and their manipulation as such properties are related to proper selection and use by the dentist their physical, mechanical & chemical properties. A science that deals with physical, mechanical, and biological properties of dental materials and their oral environment interactions. This helps select materials for particular clinical/laboratory applications; and allows him to manipulate it effectively. Therefore, the main challenge for centuries has been developing and selecting ideal dental materials to withstand the oral environment's adverse conditions. Fabric was used to fabricate (UDEX) appliances more than available in all dental clinics. It marked its easy to manipulate, well compatible with oral structure, and tolerated by the patient.

New technology benefits from the cloud-based network to help prevent and manage diseases by monitoring patients at all times using wireless sensors, cameras, or other input devices [32]. Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM), 3-Dimensional (3-D) Printing, Cone Beam Computed Tomography (CBCT), Digital records, Digital Radiography, Digital Impressions, and Teledentistry all are digital technologies utilized in nowadays dentistry that helps in diagnoses, treatment, and monitoring patients and could be part of the IoT network in dental practice [33].

Used 3D scanning device with a 3D printer with nanoscale ability to produce more accurate models on the nanoscale level. The collected data could be shared with ease anywhere, anytime with the IoT network to be analyzed, stored, and used to treat and monitor patients. After scanning the plaster casts, we will save a digital copy to the system. This digital copy could be sent to any clinic in the world via an IoT network to be analyzed; after being analyzed, it will create a diagnosis and treatment plan. Afterward, they could carry out the treatment plan after

the patients' consent. As an example of treatments that could be carried out in orthodontics, clear aligners depend on this new technology.

An orthodontic professional will analyze the scanned cast to give a treatment prescription. A 3D printer will then produce this prescription by printing 3D models to manufacture a specific set of clear aligners to treat the patient [34]. All these new technologies more than it's expensive it need allot of equipment's and experiences in works.

The new unilateral dental expander (UDEX) is simple, easy to fabricate, versatile, and useful to resolve an isolated cross bite. The advantages of this appliance are simple design, easy construction, minimal cost, and better results. It could also treat unilateral cross bite molar or Premolar as single tooth or multi teeth. In real practice, it is never too simple to obtain an asymmetric orthodontic movement of a molar or premolars due to the spatial position that the molars occupy in the oral cavity, being close to gums that can be damaged by bulky orthodontic appliances. Also, a more specific device will be easier to control, with less costs and less time to care, therefore much more tolerated by the patient and could be fabricated by an orthodontist or simple laboratory work is required. We can see a summary of the expected benefits of the new appliance in the Tab. 2.

Table 2: Summary of benefits for the new (UDEX) appliance

Application aspect	Expected improvement
Treatment time duration	Decreased by 30% to 50%
Treatment cost	Decreased by 50% to 70%
Customer satisfaction	Improved at least 100%
Customer compliance needed	Decreased by more than 40%
Effectiveness of results	Close to 100%
Safety issues caused by broken appliance	Decreased by more than 30%
Ease of use by the patient	Improved at least 200%
Ease of Fabrication	Improved at least 200%

Posterior crossbite reflects deviations from ideal occlusion in the transverse plane of space. It could be either skeletal, dental, or functional cross bite: Skeletal cross bite it could be attributed to (1) Narrow maxilla but occasionally from an excessively wide mandible (2) Hemi mandibular hypertrophy (3) Surgical treated cleft lip and palate. Dental cross bite could be attributed to Premolar or molar erupted palatally or buccally due to crowding or early loss of deciduous second molar. Functional crossbite could be attributed to mandible displaced laterally due to occlusal interference (premature contact). Dental crossbite a patient with adequate palatal width (i.e., Normal width of palatal vault Inter-molar width is approximately equal to palatal width Palatal inclination of posterior teeth). In contrast, Skeletal crossbite, a patient with adequate palatal width (i.e., Narrow palatal vault inter-molar width is considerably larger than palatal width.

There may be buccal inclination of posterior teeth as a compensation for skeletal problem) (i.e., Narrow palatal vault inter-molar width is considerably larger than palatal width).

There may be the buccal inclination of posterior teeth as compensation for skeletal problems. Also, posterior crossbite could be unilateral or bilateral. Unilateral crossbite in centric relation and maximum intercuspation without a mandibular shift caused by narrow maxillary arch combined with a functional change, that, in close examination, usually is found due to bilateral constriction

of the maxillary arch and a shift of the mandible to one side on closure. It could be a single tooth crossbite or involved multiple teeth. Bilateral posterior crossbite attribute to more severe maxillary constriction may result in a bilateral crossbite without mandibular shift. For this, the new expansion appliance is considered as a maxillary unilateral dental buccal crossbite corrector.

5 Conclusion

The new unilateral dental expander (UDEX) is an appliance proven to effectively treat true unilateral posterior crossbites as single molar or premolar tooth and multiple joint unilateral crossed posterior teeth. It could also easily modify it for future unilateral crossed purposes without effect on the non-cross side of the maxillary dental arch.

All unilateral crossbites were successfully treated with this appliance, and no crossbites were recorded at the end of the expansion treatment. This appliance was well tolerated by the patients and reduced the need for excessive patient compliance. It is also a simple appliance that is easy to fabricate, unexpansive, and provides well and practical biomechanics with superior stable results. Although cautious laboratory work is required, an orthodontist can efficiently perform by an orthodontist him/herself or sent to a lab. Technician.

Future research could be performed, adding more patients and clinical investigations. This study fabricated a handy, simple appliance using easy and available material in all dental clinics that an orthodontist can use. Intra-oral scanner or any digital program like computerized tomography (CT) and any scanning intra/extraoral and structure programs are used nowadays. Still, they are costly and not available in many dental clinics. The solution proposed by this research will solve such problems in the future.

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