Crossbite correction: learning through simulation

Learning outcomes

On reading this paper, individuals should be able to:

- identify features of anterior and posterior crossbite amenable to interceptive orthodontics;
- design upper removable orthodontic appliances for anterior or posterior crossbite correction;
- understand component adjustment for anterior and posterior crossbite correction; and,
- recognise the value of typodont teaching for correction of these occlusal anomalies.

Introduction

Anterior or posterior crossbite may be first identified in the mixed dentition. The reported prevalence of anterior crossbite is 2.2% to 11.9%, depending on the age at assessment,[1] whereas posterior crossbite is reported to affect 4% of European children and adolescents.[2] Timely interceptive correction is advised for these occlusal anomalies when associated with mandibular displacement to avert the crossbite being perpetuated to the permanent dentition. In the case of a forward mandibular displacement associated with an anterior crossbite, correction also removes occlusal trauma, which, if left untreated, may lead to incisal wear and compromise periodontal support, with resultant mobility of the opposing lower incisor.[3] On the other hand, a posterior crossbite with displacement has been associated, although weakly, with temporomandibular joint dysfunction.[2,3] Where mandibular displacement remains untreated, a posturing habit may ensue and muscular activity may become asymmetric.[3]

Correction of anterior or posterior crossbite may be undertaken using either removable or fixed appliances.[1,2] Features that make an anterior or posterior crossbite amenable to correction by orthodontic means are given in **Table 1**. The Dental Council of Ireland Accreditation Manual (2022)[4] and the Graduating European Dentist (GED) resource of the Association for Dental Education in Europe (ADEE)[5] indicate or recommend, respectively, that a graduating dentist must be able to design, insert and adjust active removable appliances to manage simple malocclusions. These would include correction of a single tooth anterior crossbite or a unilateral posterior crossbite, with associated mandibular displacement. With the reported prevalence of these anomalies, it is difficult in the undergraduate curriculum to provide sufficient clinical exposure to meet these requirements.

Table 1: Features that make an anterior or posterior crossbite suitable for interceptive correction.

Anterior crossbite	Posterior crossbite
■ Class I/mild Class III skeletal pattern with average facial proportions	■ Class I/mild Class II/III skeletal pattern with average facial proportions and no skeletal asymmetry
■ Single upper incisor in crossbite with associated mandibular displacement	■ Unilateral buccal crossbite with associated mandibular displacement
■ Upright or slightly retroclined upper incisor	■ Upright or palatal inclination of upper buccal segment teeth
■ Uncrowded or mildly crowded upper arch	■ Uncrowded or mildly crowded upper arch
■ Average to increased overbite on the incisor in crossbite	■ Well interdigitating buccal occlusion

Indeed, the challenges of imparting competency in orthodontic treatment during undergraduate education have been clearly acknowledged.[6] Final-year undergraduate dental students at four UK-based dental institutes reported a preference for case-based and practical teaching sessions in orthodontics, with less interest in lectures or problem-based learning approaches.[7] Of those open to additional teaching, 30% requested supplementary practical sessions.[7] Overall, more than 60% were interested in further teaching in interceptive orthodontics.[7] Another UK survey of final-year dental students at Cardiff University, six months prior to graduation, identified that the lowest confidence was reported in relation to design, fit and adjustment of orthodontic appliances.[8]

This paper describes two typodont models to assist in teaching design, insertion and adjustment of upper removable appliances for two cases, one for correction of a single tooth anterior crossbite and the other for correction of a unilateral posterior crossbite, both amenable to interception in the mixed dentition.

Case descriptions

Case 1

- An eight-and-a-half-year-old child with a Class I malocclusion on a Class I skeletal base, with average facial proportions and no facial asymmetry;
- upper and lower arches were uncrowded;

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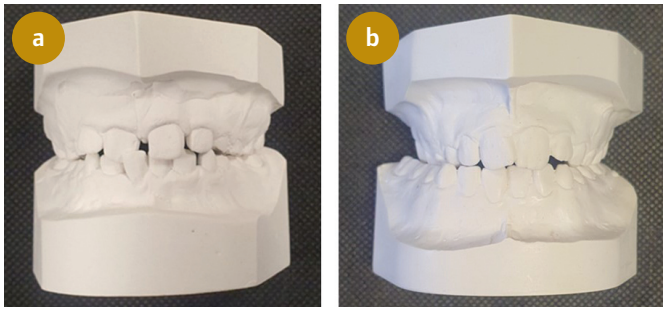

FIGURE 1: Pre-treatment study models of: (a) Case 1 showing UR1 in crossbite with LR1 displaced labially; and, (b) Case 2, showing crossbite of the upper right buccal segment.

Table 2: Details of the upper removable appliance (URA) design* for correction of each crossbite.

Anterior crossbite	Posterior crossbite
Activation: Z spring (0.5mm hard stainless steel wire) to procline UR1	Activation: Midline expansion screw**
Retention:*** Adams clasps URD and ULD (0.6mm hard stainless steel wire) Adams clasps UR6 and UL6 (0.7mm hard stainless steel wire)	Retention:*** Adams clasps URD and ULD (0.6mm hard stainless steel wire) Adams clasps UR6 and UL6 (0.7mm hard stainless steel wire)
Anchorage:**** Posterior teeth and supporting baseplate	Anchorage:**** Posterior teeth and supporting baseplate
Baseplate: Posterior acrylic capping approximately 2mm to disengage the incisors	Baseplate: Posterior acrylic capping approximately 2mm to disengage the posterior teeth

**An upper removable appliance is designed as per the acronym ARAB: A = Activation; R = Retention; A = Anchorage; and, B = Baseplate.*
***Note that a midline expansion screw, rather than a screw offset to the right buccal segment, is required for symmetrical upper arch expansion, as on initial occlusal contact the upper and lower midlines were coincident, but became discrepant on closure into maximum intercuspation.*
****Retention near to the site of proclination (clasping URD and ULD) is required to counteract the displacing effect produced on activation of the Z spring. Using a midline screw for arch expansion affords the option of clasping the teeth that need to be moved (the upper right and left buccal segments).*
*****Anchorage (resistance to the force of reaction generated by the active components) requirements are minimal where one upper incisor is being proclined with a force of 30-50g. The resultant reactionary force is dissipated via the baseplate to the other teeth and the supporting alveolus. Upper arch expansion with a midline screw uses reciprocal anchorage as the teeth being moved are also the anchor teeth.*

- UR1 was in crossbite with just over a 2mm anterior mandibular displacement from initial occlusal contact on the mesio-incisal edge of UR1; and,
- LR1 was in traumatic occlusion displaced labially and mobile.

Case 2

- A nine-year-old child with a mild Class II division 1 malocclusion on a Class I skeletal base, with average facial proportions and no facial asymmetry;

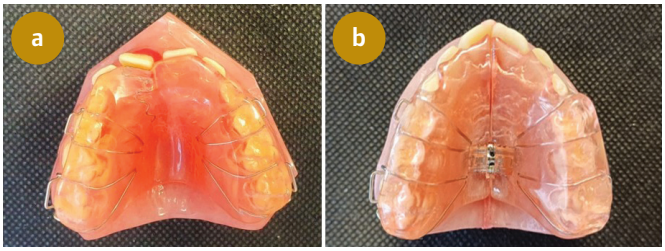

FIGURE 2: (a) Upper removable appliance to procline UR1; and, (b) upper removable appliance to expand the upper arch and correct the right buccal segment crossbite.

Table 3: Adjustment of the active components for each appliance and subsequent appliance management.

Anterior crossbite	Posterior crossbite
Active component: Z spring (0.5mm hard stainless steel wire) to procline UR1	Active component: Midline expansion screw
Adjustment for the typodont: Pull the Z spring forward 1-2 mm, ensuring that it is still resting on the mid-palatal surface of the upper incisor. Repeat activation until the crossbite is corrected.	Adjustment for the typodont: With the 'key' provided, turn the midline screw forward one turn (this gives 0.25mm activation). Repeat adjustment until the crossbite is corrected.
Clinically, reactivation of the z-spring would be on a monthly basis until the requisite tooth movement is achieved. Then, the buccal blocks should be reduced to half their height at one visit and removed completely at the following visit. Wear of the URA should be maintained until the posterior occlusion settles. Provided adequate overbite is present (one-third to half coverage of the lower incisor), wear may then be discontinued and the developing occlusion monitored.	Clinically, the screw would usually be turned twice weekly until crossbite correction is achieved. Then, the buccal blocks should be reduced to half their height at one visit and removed completely at the following visit. Wear of the URA should be maintained until the posterior occlusion settles. Provided there is good buccal segment interdigitation, wear of the URA may be discontinued and the developing occlusion monitored.

- the upper right buccal segment was in crossbite with an associated right lateral mandibular displacement on closure of 2.5mm from initial occlusal contact on the upper right and lower right primary canines; and,
- upper and lower arches were minimally crowded.

Removable appliance typodonts

Pre-treatment study models of these two cases (**Figure 1**) were duplicated in acrylic resin to produce two typodont models. For the anterior crossbite typodont model, the incisor in crossbite and associated acrylic were sectioned from the model; a 0.7mm stainless steel wire was inserted in a hole created two-thirds of the way down the incisor root, and the wire/tooth combination repositioned in the model with wax to replace the acrylic deficit. For the posterior crossbite typodont model, the model was sectioned in the midline and a 4mm wide trough of acrylic removed and replaced with wax.

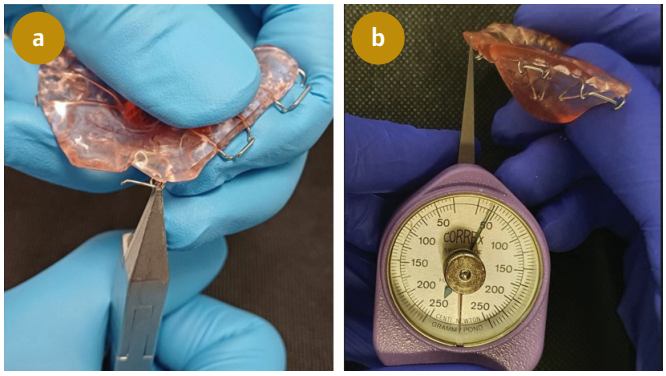

FIGURE 3: (a) Z spring being adjusted to procline UR1; and, (b) Correx gauge being used to assess force applied by Z spring (40g). Use of a Correx gauge is not essential clinically but is shown for illustrative purposes.

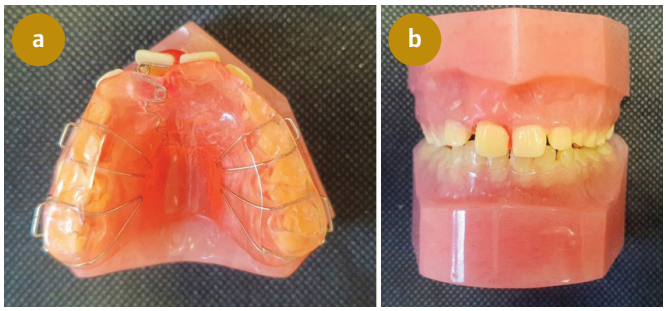

FIGURE 4: (a) UR1 moved forward (compare to Figure 2(a)); and, (b) UR1 crossbite corrected with positive overbite.

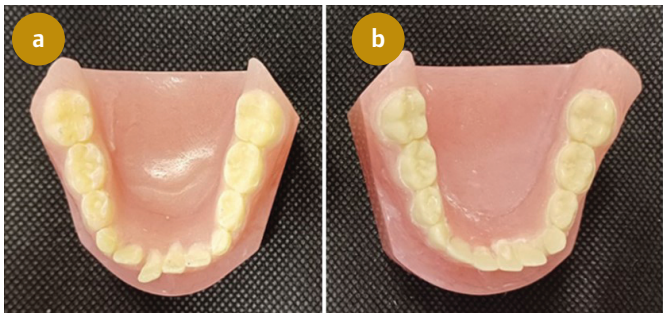

FIGURE 5: (a) Pre-treatment; and, (b) post-treatment lower models of Case 1 showing spontaneous alignment of LR1 as crossbite on UR1 was corrected.

Appliances to the descriptions outlined in **Table 2** were fabricated and fitted to each model (**Figure 2**). For anterior crossbite correction (Case 1) the Z spring was adjusted and the force measured with a Correx gauge (**Table 3**, **Figure 3**), and the appliance placed on the acrylic model, which was then placed in a hot water bath (50°C). After 10 minutes, the model was removed to assess tooth movement. Following further adjustment of the Z spring, the typodont was then replaced in the hot water bath and movement monitored until UR1 had been moved forward out of crossbite (**Figure 4**). This took four adjustments. Simultaneous lingual movement of the labially displaced lower incisor occurred clinically with disengagement of the occlusion and soft tissue pressure from the lower lip (**Figure 5**). The positive overbite on UR1 maintained crossbite correction.

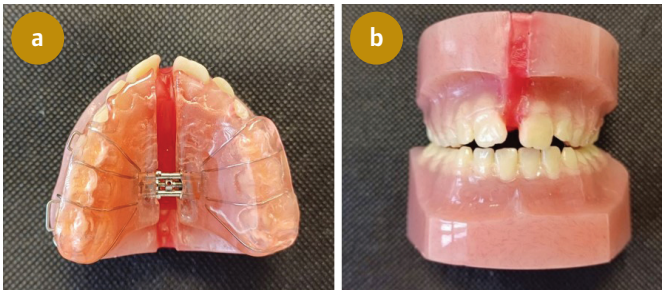

FIGURE 6: (a) Midline screw activated to correct buccal crossbite; and, (b) buccal segment crossbite corrected. Note that such a median diastema would not occur clinically with the modest force employed by the midline screw.

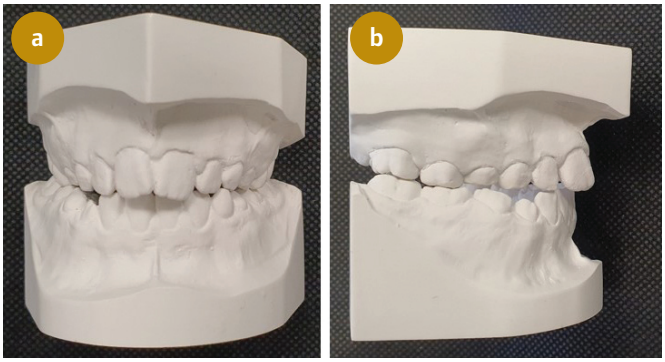

FIGURE 7: Post treatment: (a) no median diastema; and, (b) right buccal occlusion maintaining crossbite correction. Note that upper and lower midlines are now almost coincident (compare to Figure 1(b)).

For posterior crossbite correction (Case 2), the midline screw was activated one turn (0.25mm) and the typodont placed in a hot water bath (50°C) for 10 minutes and then removed to monitor tooth movement. Reactivation of the midline screw was undertaken until the crossbite was corrected (**Figure 6**). This took 12 adjustments. The interdigitation of the buccal segment occlusion maintained crossbite correction (**Figure 7**). The adjustment of the active components and subsequent appliance management are described in **Table 3**.

Benefits and limitations

Early orthodontic intervention in an undergraduate orthodontic clinic with removable appliances, or removable and fixed appliances for limited treatment outcomes, has been shown to be successful and cost effective.[9] With the current teaching objectives of the undergraduate curricula,[4,5] the high expectations of orthodontic patients,[10] and the complexity of cases eligible for treatment within the publicly funded orthodontic services in the Republic of Ireland,[11] cases suitable for upper removable appliance treatment alone are limited.[12] Apart from current use in clear aligner treatment,[13,14] removable orthodontic appliances constructed of wire and acrylic may at present be used effectively in carefully selected cases for anterior or posterior crossbite correction in the mixed dentition.

Aside from their use as an aid in undergraduate orthodontic teaching, the simulation exercises described here may also be useful for continuing professional development of dentists involved in primary care. Within the publicly funded orthodontic service, they would also allow instruction in the

provision of limited interceptive treatment for correction of some crossbite anomalies following consultant advice, and thereby reduce in part the burden placed on orthodontic treatment waiting lists.

The benefits of the simulation exercises described in this paper are that they:

- provide experience in the fitting of two standard removable appliances for anterior and posterior crossbite correction;
- give an opportunity to adjust active and retentive components on these appliances;
- allow tooth movement to be monitored following adjustment of the active components;
- simulate a course of orthodontic treatment in a condensed timeframe;
- provide a 'hands-on' learning opportunity, which can be repeated until the desired outcome is achieved;
- facilitate timely and constructive feedback; and,
- have a modest cost.

The limitations include:

- the time required to construct the models;
- the need for a hot water bath;
- wax does not mimic alveolar bone;
- settling of the occlusion cannot be reproduced; and,
- wax needs to be replaced following successful completion of each exercise.

Various types of typodont models have been used in undergraduate orthodontic programmes to assist with teaching adjustment of removable appliance components.[15,16] Recently, there have been developments in virtual reality technology, haptics (enabling a sense of touch), and robotics in dental simulation.[17] Haptic simulation has been shown to be a useful adjunct to phantom head teaching,[18] providing real-time sensory feedback and a more optimal sense of a clinical procedure, which enhances the student learning experience.[17] It would appear that such a system has not been developed for orthodontic simulation of the case types outlined in this paper, but in the future this may be produced. As curricula in orthodontic undergraduate education evolve,[6,19] with a likely greater emphasis on acquisition of diagnostic rather than therapeutic skills, the simulation exercises described here and similar may be useful in provision of a brief exposure to what limited interceptive measures can achieve with targeted case selection.

Conclusions

- Anterior or posterior crossbite may be amenable to correction in the mixed dentition by removable orthodontic appliances; and,
- instruction in appliance design, as well as fitting and component adjustment of these appliances, is afforded by typodont models.

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References

1. Borrie F, Bearn D. Early correction of anterior crossbites: a systematic review. *J Orthod.* 2011;38(3):175-184.
2. Ugolini A, Agostino P, Silvestrini-Biavati A, Harrison JE, Batista KB. Orthodontic treatment for posterior crossbites. *Cochrane Database Syst Rev.* 2021;12(12):CD000979.
3. Fleming PS, Johal A, DiBiase AT. Managing malocclusion in the mixed dentition: six keys to success. Part 1. *Dent Update.* 2008;35(9):607-610, 612-613.
4 Dental Council of Ireland. Dental Council Accreditation Manual – January 2022. Dental-Council-Accreditation-Manual-2022_to-Schools.pdf (dentalcouncil.ie). Accessed August 15, 2024.
5. Association for Dental Education in Europe. Graduating European Dentist Curriculum. Published April 21, 2020. https://adee.org/graduating-european-dentist/graduating-european-dentist-curriculum. Accessed August 15, 2024.
6. Raghavan S, Abu Alhaija E, Ali K. Orthodontic curricula in undergraduate dental education—a scoping review. *Int J Environ Res Public Health.* 2023;20(6):4914.
7. Jauhar P, Mossey PA, Popat H, Seehra J, Fleming PS. A survey of undergraduate orthodontic teaching and factors affecting pursuit of postgraduate training. *Br Dent J.* 2016;221(8):487-492.
8. Gilmour ASM, Welply A, Cowpe JG, Bullock AD, Jones RJ. The undergraduate preparation of dentists: confidence levels of final year dental students at the School of Dentistry in Cardiff. *Br Dent J.* 2016;221(6):349-354.
9. Bernas AJ, Banting DW, Short LL. Effectiveness of phase 1 orthodontic treatment in an undergraduate teaching clinic. *J Dent Educ.* 2007;71(9):1179-1186.
10. Sayers MS, Cunningham SJ, Newton JT. How do you identify the patient with 'high expectations' of orthodontic treatment: an empirical approach. *J Orthod.* 2020;47(4):289-293.
11. Scott C. Understanding the IOTN. *J Irish Dent Assoc.* 2015;61(5):236-239.
12. Littlewood SJ, Tait AG, Mandall NA, Lewis DH. The role of removable appliances in contemporary orthodontics. *Br Dent J.* 2001;191(6):304-306, 309-310.
13. d'Apuzzo F, Perillo L, Carrico CK, *et al.* Clear aligner treatment: different perspectives between orthodontists and general dentists. *Prog Orthod.* 2019;20(1):10.
14. Johal A, Bondemark L. Clear aligner orthodontic treatment: Angle Society of Europe consensus viewpoint. *J Orthod.* 2021;48(3):300-304.
15. Jones ML, Volp C. A 'mini-typodont' for removable appliance teaching. *Br J Orthod.* 1989;16(4):277-279.
16. Mirmoghtadaie Z, Seifi M, Namdari M, Eskandarloo F, Amdjadi P. Effectiveness of educational intervention with non-wax and virtual typodont methods in practical orthodontic course of dental students, Shahid Beheshti University of Medical Sciences. *J Dent School, SBUMS.* 2023;40(2):67-72.
17. Farag A, Hashem D. Impact of the haptic virtual reality simulator on dental students' psychomotor skills in preclinical operative dentistry. *Clin Pract.* 2021;12(1):17-26.
18. Huang Y, Huang S, Liu Y, Lin Z, Hong Y, Li X. Application of virtual reality and haptics system Simodont in Chinese dental education: a scoping review. *Eur J Dent Ed.* 2023:10.1111/eje.12984.
19. Agou S, Alansari R. Defining orthodontic learning outcomes for general dentists: a modified Delphi process-based curricular modification. *Semin Orthod.* 2024;30(4):413-421.