Twin-slots Bracket: A New Vision for Efficiency of Tooth Movement

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The aim of the study was to design a bracket structure that features two parallel rectangular slots. This Twin-slots bracket separates the embedment of two archwires and therefore forms a force-acting area between the archwires and the slots, creating a large amount of force moment. With the tooth displacement being guided and controlled within the track of two archwires, some modalities of tooth movement that require heavy force moment, such as mesio-distal bodily translation, de-rotation and uprighting, could be manipulated efficiently. A variety of options in the combination of two different archwires mean they function independently but integrally to fulfil complex teeth repositioning, e.g. relieving severe crowding in anterior teeth while reinforcing the anchorage in the molars, and retracting the anterior teeth by one archwire performing labial-lingual tipping while the other adjusts torque.

A case report was provided to demonstrate its clinical application. This design is a preliminary attempt and further improvement in the slot structures, such as the built-in prescriptions, should be the subject of further research.

Key words: *force moment, main and auxiliary archwires, twin-slots bracket*

Since its introduction to clinical practice, the edgewise technique has been the target of numerous advances and modifications, aiming to improve its efficiency in tooth movement control[1,2]. The evolution of bracket structures from original rectangular to built-in prescriptions reflects the continual pursuit of orthodontic professionals for better management of tooth displacement. In the context of the edgewise technique, the changes in the bracket structure began with the ancestral design of the vertically positioned slot in the Ribbon Arch Appliance, to the pure rectangular horizontal-slot in the traditional Standard Edgewise, to the contemporary pre-adjusted brackets in the Straight-wire technique and to the current design of the self-ligating brackets system[3,4]. It is interesting to note, however, that despite a variety of bracket designs, one thing remains unchanged: there is not more than one horizontal slot on the facial facet of the bracket.

It is well accepted that in a severe crowding case, the twin-archwires mechanism can be adopted where the rigid main archwire reinforces the anchorage and the resilient auxiliary one helps to reposition the severely malaligned teeth, e.g. the lingually positioned upper lateral incisors[5]. However, the engagement of two archwires into a single slot seems difficult to handle clinically, and their respective functions might be disturbed as the two archwires are close together. Moreover, the limited width and depth of the slot prevents the engagement of a main archwire of considerable size. Another scenario in which single slot bracket is less efficient is the management of tooth movement requiring high force moment, e.g. bodily mesiodistal translation, de-rotating and uprighting[6,7]. It is not a rare occurrence that distali-

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Fig 1 The Twin-slots bracket features two parallel 0.022" slots. The geometric form of the slots is rectangular with no built-in angulations at this preliminary stage.

sation of a canine towards the extraction space ends up with unfavourable tipping, rotating or even elongating. This might be due to the fact that the bracket width is limited so that the force moment created within the slot is not sufficient to facilitate a bodily movement of the canine[8].

We report a new design of bracket structure, the Twin-slots bracket, in an attempt to provide a possible solution to the above-mentioned issues and a new option for control of tooth movement.

Appliance Design and Construction

The preliminary design for the prototype bracket was based on the traditional Standard Edgewise appliance. The two horizontal slots in parallel were set on the facial facet of the bracket, with a separation width of 0.4 mm. This considerably distanced the two slots without a significant increase in the bracket height. The size of the two slots was conventional, 0.022" x 0.028". The overall size of the bracket was 2 x 3.5 mm^2. The geometric form of the slots was 90º rectangular with no built-in prescriptions (Fig 1). Further modifications to the Twin-slots bracket with built-in prescriptions could be attempted if the preliminary version proves effective.

The prototype brackets of the design, together with the corresponding molar tubers, were manufactured by a professional bracket manufacturer based in Shanghai and were authorised for clinical trial (Chinese National Patent Approval No. IL 032 29330.5).

Mechanism of Twin-slots Bracket

The magnitude of the force moment generated within the bracket is a crucial factor in determining the efficiency in tooth repositioning. The bodily mesiodistal movement, such as the canine distalisation, could only be successful with the support of strong force moment created within the bracket slot[9]. Rigid force moment is also a prerequisite to secure some other types of tooth movement, such as uprighting or de-rotating of the severely malpositioned tooth[10]. The building-up of an additional slot in the Twin-slots bracket could result in a two-fold increase of force moment compared with the routine single slot bracket, leading to an increased effectiveness in various modalities of tooth movement, including bodily translation (Fig 2a), uprighting (Fig 2b) and de-rotating (Fig 2c).

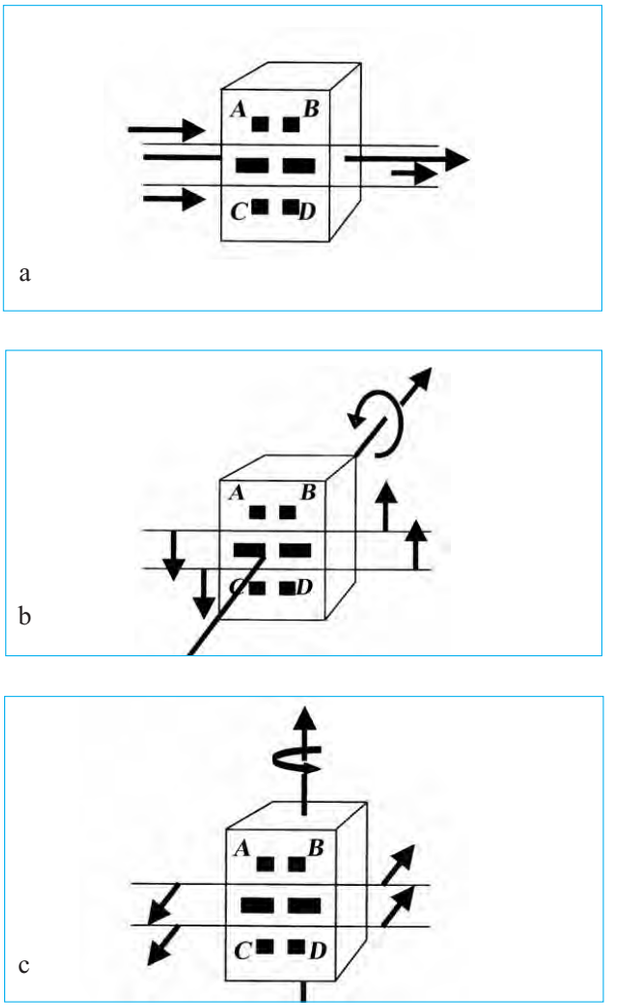

Fig 2 Diagrams depicting the mechanism of force action by the two archwires against the Twin-slots bracket in tooth movements that require strong force moment. The four-point contacts between the archwires and slots (A, B, C, D) form a force-acting area that generates a considerable amount of force moment to facilitate tooth mesio-distal bodily translation (a), uprighting (b) and de-rotating (c).

The separate accommodation of the two archwires in the two slots also results in four contacting points within each individual bracket between the archwires and slots, which constitute a force-acting area. This is unlike

the situation in the single slot bracket where two contacting points between the archwire and the slot form a force-acting line. Tooth movement controlled and guided by the force distributed around the whole bracket area would not be likely to cause tipping and rotating, the unfavourable movements that often occur in the single slot mechanism.

Clinical Application

The Twin-slots bracket is suitable for the corrections of a variety of malocclusions, especially those with severe crowding. This is due to the fact that this bracket can generate adequate force moment within the twin-slots and therefore is capable of displacing severely malpositioned teeth. The archwire sequence with the Twin-slot bracket follows that of the routine brackets: the treatment begins with small, soft, round archwires and progresses to larger, rigid, rectangular archwires. Under certain circumstances, such as a relief of severe crowding that requires maximum anchorage, the levelling process may begin with a main rigid, round archwire to consolidate the anchorage, together with an auxiliary soft archwire to activate the displacement of the malpositioned teeth. Double-archwire engagement is encouraged with the use of the Twin-slots bracket because of the potential advantage of the combined properties of the two archwires. However, single-archwire engagement may be optimal where the alignment of the teeth has been achieved or the treatment is toward its final stages. When engaging with a single archwire, the selection of the slots (gingival vs incisal) depends on such factors as the depth of overbite, the accuracy of the bracket positioning, and the treatment goal of the vertical dimension (intruding vs extruding). Descriptions detailing the clinical application of this bracket follow.

Main and auxiliary archwires

The Twin-slots bracket separates the embedding of the main and auxiliary archwires, which enables the twin-archwires mechanism to work more efficiently than if the two achwires were engaged within a single slot. The main archwire is usually rigid and is attached to as many of the teeth as possible to reinforce the anchorage by consolidating the frame of the dental arch, whereas the auxiliary archwire, usually flexible and resilient, is ligated with the malaligned teeth to reposition them into the right places (Fig 3a). The separation of the two archwires has also made it possible to employ a heavy main archwire at the very beginning stage of treatment in severely crowded cases where the maximum anchorage should be secured at the start. The routine use of light, resilient archwire at the initial stage to relieve crowding might account for the early loss of the molar anchorage.

Various combinations of two archwires

The Twin-slots bracket provides a variety of options and choices for the combinations of the two different archwires. Two archwires with different properties (soft vs rigid), different shapes (round vs rectangular) and different sizes (small vs large) could co-exist to function independently but harmoniously, leading to an efficient manipulation in tooth repositioning. The combination of two resilient, small, NiTi, round wires will work well to initiate the crowding relief if moderate or mild anchorage is required. Two rigid, round wires are combined to facilitate bodily movement of the canine into the extraction space (Fig 3b). When it comes to the stage of anterior retracting and space closing, a large, rectangular wire could be integrated with a large, rigid, round wire, with the former to control and adjust the torque of the anterior teeth while the latter, with the closing loops or the hooks, retroclines and retracts the anterior teeth (Fig 3c). In this way, the task of tooth inclination adjustment and tooth retraction are separately designated and executed by the two archwires, making the closing of the extraction spaces more efficient.

Flexible engagement approaches

The bracket structure with two slots provides many alternatives in archwire engagement. The traditional single-archwire engagement is still an option with the Twin-slots bracket when necessary, e.g. in the situation where severe crowding has been relieved and the teeth are in an acceptable alignment. In some cases, a differential engagement mechanism can be adopted where the twin archwires are employed in one dental arch with severe crowding, whilst the single archwire is tied to the other in which an initial alignment is achieved. In cases with deep curve of Spee, a rectangular, NiTi wire could be engaged into the occlusal slots at the labial segment and then transferred into the gingival slots at the buccal segment. By doing so, the archwire is deformed into a reverse curve shape and therefore could facilitate flattening of the curve of Spee.

Case report

Clinical assessment

An 18-year-old male presented with the chief complaint of severely crowded teeth. He had an apparent convex lateral profile with the competent lips. The intraoral ex-

Fig 3 The clinical application of the Twin-slots bracket allows the flexible combinations of two archwires for a better manipulation of tooth movement. (a) A heavy archwire combined with a light one works to replace the malpositioned teeth with a secured anchorage. (b) The combination of the two rigid archwires keeps the canine upright during its distalisation. (c) The combination of a round and rectangular archwires achieves an anterior en masse retraction with a simultaneous torque adjustment.

amination revealed severe crowding in the maxillary and mandibular anterior teeth, with the upper laterals being lingually positioned. The maxillary and mandibular incisors were proclined and the lower curve of Spee was deep. A 4 mm overjet and 2 mm overbite were identified. The canines and molars occluded in a Class I relation (Figs 4a to 4c). The panoramic radiograph revealed no pathosis in the roots and supporting tissues. However, superficial caries was identified in the left upper lateral, which was half-overlapped with the central. Cephalometric analysis confirmed a skeletal Class I relationship and the proclined upper and lower anterior teeth. The treatment plan was extraction of the four first premolars to allow for a relief of crowding and retraction of the proclined upper and lower anterior teeth. Maximum anchorage was intended to secure anterior crowding relief and to maintain the Class I molar relation.

Canine distalisation and crowding relief

The treatment started with the canines being moved distally towards the extraction space. A 0.016" stainless steel, round archwire, together with a 0.016" NiTi, round archwire (3M Unitek, USA) were placed in both the upper and lower dental arches. In the crowding area, the 0.016" stainless steel archwire was adjusted by adding some bends in accordance with the irregularities of the teeth to allow for a passive engagement and therefore to reinforce the anchorage. At this stage, the severely malpositioned teeth, e.g. the upper and lower laterals, were not bonded. The distalisation of the canines was initiated by a lace-back mechanism, and proceeded with the use of power chains (3M Unitek). Sliding alongside the track consisting of the two archwires, the canines were kept upright when moving distally (Figs 4d to 4f).

With the canines moving away from the labial segment, the laterals were bonded and a 0.018" stainless steel, round archwire, together with a 0.014" NiTi, round archwire (3M Unitek) were placed in both the upper and lower dental arches. While the rigid wire was used to secure the anchorage and to maintain the fundamental framework of the dental arch, the light wire acted to displace the malpositioned teeth, namely the laterals.

Anterior tooth retraction and space closure

The completion of anterior alignment was followed by the retraction and/or retroclination of the upper and lower anteriors. A 0.019" x 0.025" stainless steel, rectangular archwire together with a 0.016 stainless steel, round

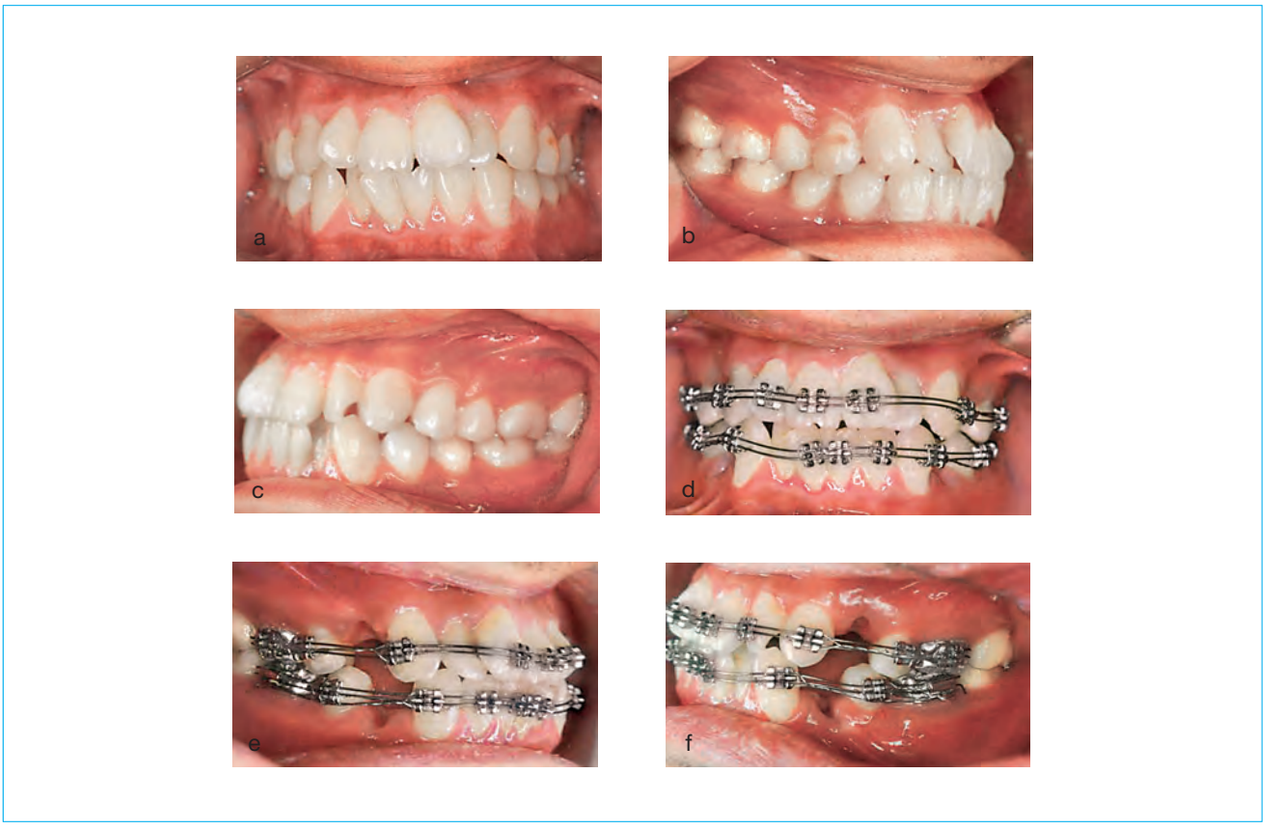

Fig 4 A case with Class I crowding treated by the Twin-slots brackets.
(a to c) Original malocclusion of Class I dental and skeletal relation with the severely crowded anterior teeth and moderate bimaxillary proclination.
(d to f) The Twin-slots appliance treatment started with partial brackets placement to bypass severely malpositioned teeth, followed by a two-archwire engagement for crowding relief and canine bodily distal translation.

archwire (3M Unitek) was imposed in each of the dental arches for this purpose. The anterior retraction was achieved by activating the closing loops in the round archwire, and simultaneously adjusting the anterior inclination (torque) with the rectangular archwire, in which excessive root-lingual torque was implemented to compensate for the torque lost during the tipping of the anterior teeth.

The correction of the deep curve of Spee in the lower dental arch was commenced after the initial relief of the crowding. A 0.018" x 0.025" NiTi archwire (3M Unitek) was placed, and flattening of the curve of Spee was achieved by engaging the archwire into the gingival slots at the buccal segment and transferring to the occlusal slots at the labial segment. This unique archwire placement could enforce the intrusion of anterior teeth and concomitantly allow for elongation of the posterior teeth. The single 0.019" x 0.025" stainless steel rectangular artistic archwire (3M Unitek) in both of the dental arches was placed for finishing and detailing (Figs 4g to 4i). It is suggested that for the Twin-slots appliance the engagement of a single archwire is also an option if necessary, e.g. in the finishing and detailing stage.

Treatment outcome

The patient's profile was improved by reduction of the convex contour. The natural lip disclosure indicated an elimination of the lip incompetence. The maxillary and mandibular teeth were in good alignment, with the canines and molars in a Class I relationship. The maxillary and mandibular anterior teeth were in good relation, manifested by 2 mm of overjet and overbite. The lower curve of Spee was also a good shape (Figs 4j to 4l). The cephalometric analysis revealed an improved anteroposterior inclination of the anterior teeth and an acceptable

Fig 4 (g to i) Towards the end of the treatment, a single-archwire approach was adopted for detailing.
(j to l) The case was completed when the sound alignment and retraction of the anteriors were achieved and the Class I inter-dental and skeletal relation was maintained.

Class I skeletal relationship between the maxilla and mandible.

Summary

- The structure of the Twin-slots bracket features two parallel slots on the facial facet of the bracket.
- Four-point contacts between the archwires and slots in the bracket constitute a force-acting area, which significantly increases force moment.
- A variety of the combined choices of the archwire engagement enhances the efficiency of tooth repositioning, such as de-rotating, tipping or uprighting and bodily translating.

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