repercussions on their social life. Because the possibility of arch expansion in these patients is limited, clinicians must often opt for an extractive treatment and full canine retraction followed by en masse retraction of the six anterior teeth as a single unit [6–8], to avoid unsightly space between the lateral incisor and canine during the treatment. This, however, requires greater orthodontic forces and consequently increases the likelihood of side effects and loss of anchorage.

As a matter of fact, it is advisable in frictional space closure to use lighter forces and heavier wires with a stiffness able to counteract the negative effect of elastic chain forces [6, 7] reducing the vertical and horizontal bowing effect and providing good finishing and optimal space closure. As the stiffness of a wire is inversely proportional to its length [8–10], it has been hypothesised that a straight lingual archwire, being shorter than the corresponding mushroom archwire, should aid the clinician in keeping bowing effect under control [11–13].

We set out to test this hypothesis by investigating the relative stiffness of different mushroom and straight-form lingual archwires for both arches in vitro, using a modified three-point bending test and plotting their load/deflection graphs. Many previous studies have investigated the relative wire stiffness comparing lingual and labial archwires, respectively [9, 14], but they have tended to focus on interbracket distance and its correlation with archwire stiffness during the initial alignment and levelling phase, whereas we decided to focus on the final stage of lingual orthodontic therapy, namely extraction space closure with sliding mechanics.

To our knowledge, no study has yet been conducted with the aim of comparing the stiffness of two different lingual archforms used for en masse retraction in extraction space closure. We therefore set out to test the above hypothesis, with a view to confirm the suitability of the lingual straight wire system for space closure mechanics and to identify the most suitable working lingual archwire as regards shape, size and alloy.

Methods

A 3D virtual model set-up (Orapix system), based on a single ideal patient with moderate crowding, was generated and used to design one set of mushroom archwires—upper (UMW) and lower (LMW)—and one set of straight wires (SW)—upper (USW) and lower (LSW)—according to the Scuzzo-Takemoto method (Figs. 1 and 2).

ImageJ software was used to measure the length of all archwires, and the exact respective differences in length between the straight and the mushroom wires of both arches were calculated as a percentage proportion. We used these virtual measurements to cut the real archwires to the same lengths at their straightest distal portion, and the percentage proportion calculated was used as a basis to obtain the real length of the mushroom archwire samples including their inset bends. Five types of sample wire were tested in this study, namely 0.016 × 0.016-in. SS, 0.016 × 0.022-in. SS, 0.018 × 0.018-in. SS, 0.018 × 0.025-in. SS and 0.0175 × 0.0175-in. β-Ti. The archwires were provided by Ormco (Orange, CA, USA) (Table. 1).

Each sample was mounted as an edgewise wire in four vestibular passive self-ligating brackets (slot 0.022 × 0.028 in.; Damon 3Mx, Ormco) that had been glued to an acrylic resin base in such a way as to create a 16-mm span between the internal sides of two adjacent brackets.

The study followed the ISO 15.841 guideline to perform orthodontic test [15]. So each wire was subjected to a three-point bending test, modified to simulate clinical conditions as accurately as possible [16]. An Instron 4467 dynamometer (Instron, Norwood, Mass) connected to a 100-N load cell was used to regulate the force applied, and archwire deflection was achieved via a metal blade, with a curvature range of 1 mm at its extremity, fixed to the load cell.

Each wire was deflected 1 mm, at a deflection speed of 1 mm/min (Fig. 3). To obtain reliable data, we tested each wire three times. The bending stiffness of each wire was then determined by plotting a force/deflection graph

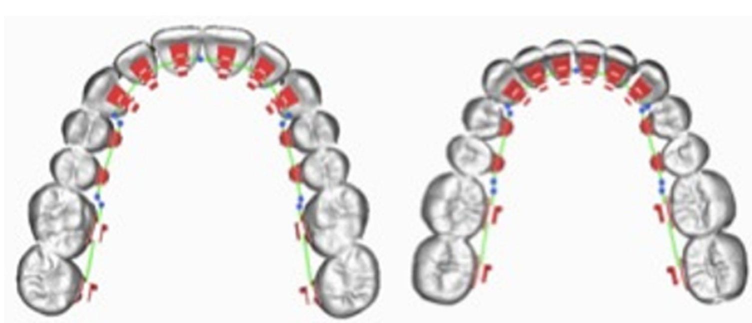

Fig. 1 Digital set-up of an ideal patient with moderate crowding using a lingual mushroom archwire (UMW and LMW)