

the teeth [20, 21]. Furthermore, the stiffness characteristics of an expander must be increased when a patient presents with a particularly deep palate [22].

In this regard, the use of miniscrews to stabilize RPEs seems to be helpful, especially in late adolescence, and is currently the focus of ongoing research [23, 24]. However, to date, available data is scarce. For example, Muchitsch et al. [25] analyzed only the mechanical characteristics of the arms of RPEs, while Camporesi et al. [26] analyzed the compressive forces developed at each activation of three types of expander screw.

With a view to reducing patient discomfort and facilitating oral hygiene procedures, manufacturers are developing and marketing increasingly less bulky, more streamlined RPEs [27, 28], and we set out to evaluate the stiffness characteristics of several such devices.

## Methods

The experiment evaluated 10 of the rapid expansion screws found on the market, all in medical-grade stainless steel (see Table 1 for details). Seven of the expansion screws had four retention arms and three had two retention arms. Each was welded to orthodontic bands and evaluated for overall stiffness, which comprised not only the stiffness of the screws themselves but also the resistance of the entire structure, including the welded joints. The deformation of the screws alone was not tested, as enormous forces would need to be measured.

### RPE construction

Each screw was used in the construction of an RPE modeled on average values derived from measurements

made on 100 expanders constructed to fit 100 Caucasian patients (54 females and 46 males) aged between 8 and 13. All patients of the sample needed a RPE treatment. The patients already treated by orthodontics were excluded. This age range was chosen because the RPE allows favorable orthopedic changes and it is widely utilized by patients of this age.

The measurements made on these 100 RPEs were as follows: (1) length of the anterior arms comprising the screw body; (2) length of the posterior arms comprising the screw body; (3) bend angle of the anterior arms; and (4) bend angle of the posterior arms. A copper wire shaped to fit the morphology of the retention arms was used to perform these measurements, which were made using a goniometer (angular measurements) and gauge (linear measurements). All measurements were performed by the same operator, and the sample means calculated are reported in Table 2.

Two metal wires (one for the anterior arms and one for the posterior arms) of 0.8-mm diameter were used to transfer these values to a plaster model of standard upper arch (Fig. 1). A set-up was performed to adapt the standard arch form to the means obtained from our measurements.

The first molars were removed from these models and replaced with analogous metal teeth, joined together by means of a threaded pin to ensure that they remained parallel and that the RPEs constructed around them would be correctly aligned with the mechanical testing machine; an Instron 4467 (Instron Corp., USA) with 500-N load cell was to be used for the stiffness testing.

Before testing, the metal teeth were fixed to the plaster model using wax to create a master model, duplicated

**Table 1** Screw characteristics

Two-arm screws	Max. expansion	Arm Ø (mm)	Screw body size (mm)	Amount of expansion per activation (mm)	Lot no.
Dentaurum Variety S.P. two-arms	12	1.48	9.6 × 5 × 3	0.8	435299
Veltri Target baby REP	13	1.45	11 × 6 × 4.5	0.8	700032
Leone A 362113 two-arms	13	1.48	10 × 6 × 4.5	0.8	12032901
Four-arm screws	Max. expansion	Arm Ø (mm)	Screw body size (mm)	Amount of expansion per activation (mm)	Lot n°
Lancer Philosophy 1	10	1.55	8 × 8 × 3.5	0.8	RPE OOO440
Dentaurum Hyrax Click Medium	10	1.48	10 × 11 × 4	0.8	435361
Forestadent Anatomic Exp. Type "S"	10	1.48	12 × 7 × 3.5	0.8	48297815
Forestadent Type "S" for narrow palates	10	1.48	12 × 7 × 3.5	0.8	7399006
Forestadent Memory	10	1.48	15 × 10 × 4	0.8	14957593
Leone A 2620-10 with telescopic guides	10	1.48	14 × 11 × 4	0.8	12122001
Leone A 0630-10 with orthogonal arms	10	1.48	10 × 6 × 4.5	0.8	13011601