

BENEFICIAL FRICTION

MAXIMIZING EFFICIENCY WITHOUT COMPROMISING CONTROL

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INTRODUCTION

Studies of orthodontic frictional resistance, which quantify and compare mechanical efficiency in vitro, may be biased towards minimization of friction. Optimal tooth movement, however, is not necessarily predicated on minimization of friction because in vivo positional control requires finite frictional resistance localized to the wire-bracket-ligation interface.

METHOD

In a retrospective series of case reports, orthodontic treatment objectives were assessed in patients subjected to a standardized protocol of dental rotation and/or crowding correction. Patients were followed with intraoral photography and assessed qualitatively relative to duration of archwire placement.

MATERIALS

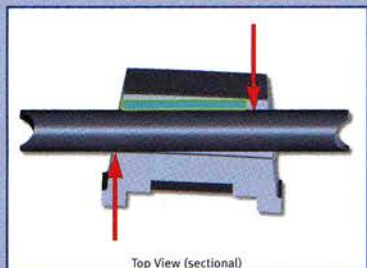
All patients were treated with superelastic alloy archwires in combination with interactive bracket mechanics. All patients received preadjusted SPEED System™ brackets (Strite Industries Limited) of .022 inch slot size and the Hanson prescription. All initial archwire placements utilized SPEED Supercable™ superelastic nickel-titanium archwire consisting of 7 strands with a long-pitched wrap. In some cases the 'straight' core wire was removed leaving the 'wrap' wires in the form of a tube.



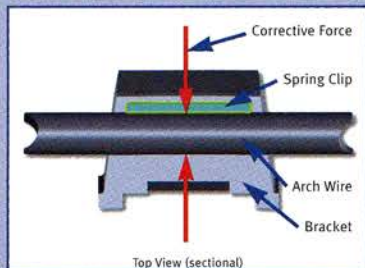
Archwire causing as much torsional and frontal spring-clip deflection as the protector slot will allow. More than 10 kilograms of force can be applied in this way without escape of the archwire or plastic deformation of the spring-clip.



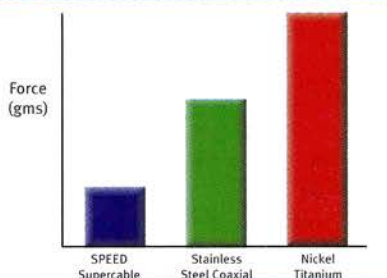
Bracket mechanism acquiring an attitude of static equilibrium relative to the archwire (theoretically occurring with absolute precision). No deviation from this spatial relationship is possible without additional elastic deflection of the spring-clip.



Viewed in section from above, forces acting upon the archwire are seen to be equal and in opposite directions. The largest rotational couple is generated when the forces are furthest apart.



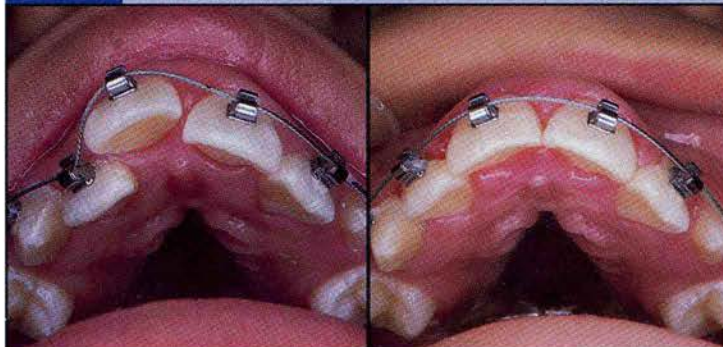
The spring-clip is sufficiently pre-stressed to maintain effective couples up to the point at which the opposing forces become collinear and the mesial and distal gaps between archwire and bracket slot are equal.



Supercable contains multiple, long-pitch strands of superelastic nickel-titanium wire and exhibits extremely low-force superelastic behaviour. In all but the most extreme of deflections, the archwire configuration allows full engagement with complete elastic recovery and no plastic deformation.

.016 Supercable exerts, on average, 1/5 the force of .016 Nickel Titanium Wire and 1/3 the force of .016 Steel Coaxial Wire.

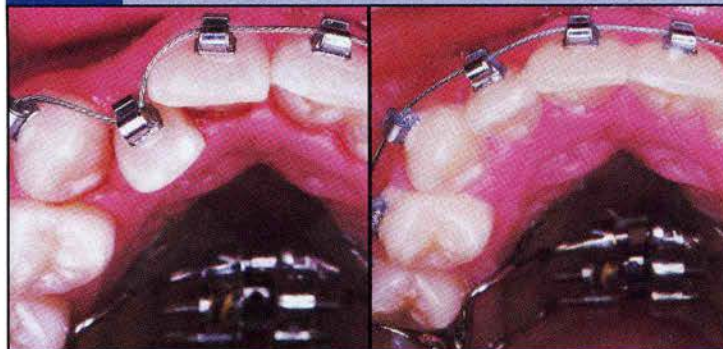
CASE 1



Initial .016 Supercable at DAY 1 of treatment.

Same .016 Supercable at DAY 48 (6.9 weeks).

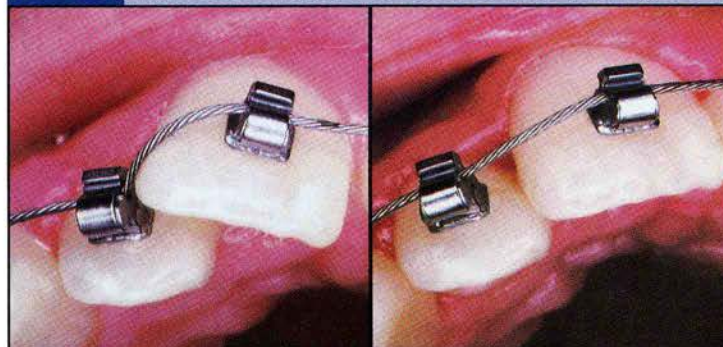
CASE 2



Initial .016 Supercable at DAY 1 of treatment.

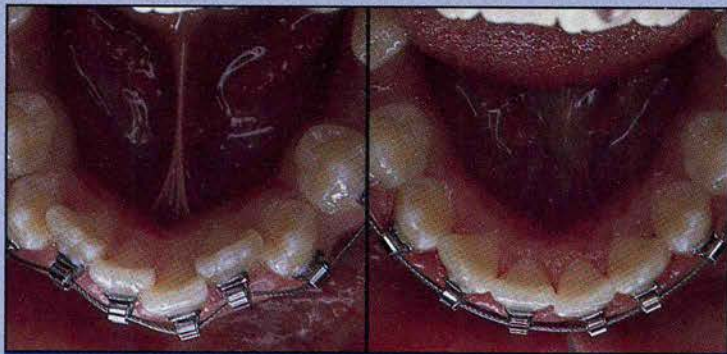
Same .016 Supercable at DAY 48 (6.9 weeks).

CASE 4



Tubular .016 Supercable at DAY 1 of treatment.

Same .016 Supercable at DAY 48 (6.9 weeks).



Initial .016 Supercable at DAY 1 of treatment.

Same .016 Supercable at DAY 58 (8.3 weeks)

DISCUSSION

The SPEED appliance permits precision in the three-dimensional control of tooth movement and has the capacity to store energy for release at a desirably slow rate.^{2,3} For example, the spring-clip may be activated upon archwire engagement, by its elastic displacement from the occlusogingival (rotational) axis of the bracket. The torsional component of the spring-clip displacement creates a rotational couple that is actively maintained until elastic recovery of the spring-clip deflection occurs and the rotational forces become collinear. Correction of dental rotation is therefore achieved, in part, through torsion and subsequent elastic recovery of the spring-clip deflection.³

Dental rotational correction is also a function of archwire superelastic recovery and its relation to interbracket distance. Despite availability of highly effective superelastic archwires, light archwire forces and amounts of tooth movement per adjustment depend more on interbracket width than archwire size.⁴ For example, a 50% increase in interbracket distance (i.e. a single interbracket width 1.5 times a twin interbracket width) decreases the interbracket wire stiffness by a factor of $(1.5)^3 = 3.37$ times (for bending). Assuming operation within the elastic limits of a given archwire, a bending force that will move a tooth 0.5mm with wider brackets will effect 1.7mm of movement using narrower brackets.⁴ Alternatively, increased interbracket distance allows archwire deflection of lower force magnitude thereby taking advantage of the resilient deflective action of the bracket spring-clip.³

As an example of an interactive single bracket, the SPEED appliance has been used successfully for more than 15 years.^{1,3,5-8} Anecdotal reports of the appliance causing undesirable archwire friction are inaccurate.⁹ Although one study showed large axial rotation moments causing archwire binding (under conditions of high force loading), the same authors¹⁰ reported the appliance delivered the least force over the greatest range of axial rotation.^{9,10} Finite frictional resistance provided by elastic spring-clip torsion, in combination with superelastic archwire deflection, affords clinical efficiency without compromising positional control.¹¹

CONCLUSION

Optimal tooth movement is not necessarily predicated on minimization of friction because in vivo positional control requires finite frictional resistance localized to the wire-bracket-ligation interface. In this sense, light frictional resistance may be considered beneficial for clinical control of tooth movement. Our observations suggest there is a range of beneficial friction maintained by the wire-bracket-ligation interface affording efficiency of tooth movement without compromising positional control.

REFERENCES

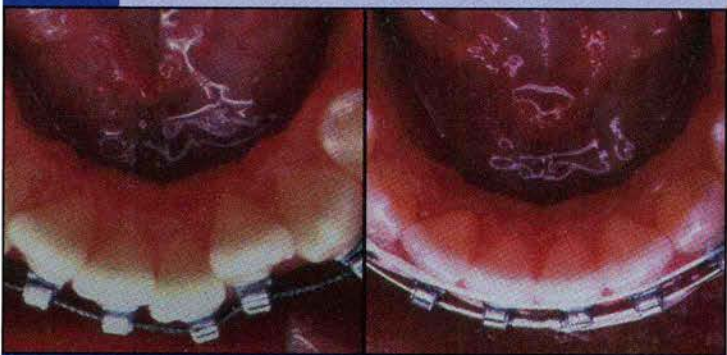
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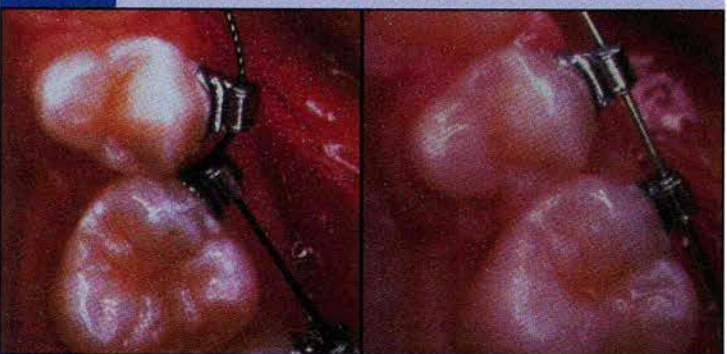
CASE 3



Initial .018 Supercable at treatment DAY 1

.020 NiTi placed at DAY 128 (18.3 weeks).

CASE 5



Initial .016 Supercable at treatment DAY 1

Rotational control at t=8 months (32 weeks).