Selection of the Square and Rectangular Wires in Clinical Practice

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With some exceptions, square and rectangular wires are used after rotations have been taken out of the arch and the arch form is nearing its final shape, which does not mean its final arch length. It is true because the square and rectangular wires are quite a bit stiffer in both planes of bending; therefore, the square and rectangular wire will help in leveling the bracket slots in small magnitudes of perhaps .005 to .010 inches but, beyond these distances, they are of little value as leveling wires. Probably the exception to this generalization is the .016 x .016 wire which is used as a leveling wire because of its equal range in both the flat and edgewise plane of bending compared with the .016 round wire.

The majority of rectangular wires are used primarily after leveling and for their torsion characteristics. In other words, they are used mainly to "torque" or "upright" roots that have been tipped in all three planes of space. These observations seem rather clear, but what is not so clear is the transition of changing archwires from the round more resilient wire to the square or rectangular stiffer wire. The choices of selecting the square and rectangular wires are more difficult; because what one gains in the "torquing" characteristic of the wire, he generally loses with the wire's increased stiffness, i.e., the wire is stiffer and its ability to level is decreased. This stiffer wire also loses its ability to finish rotating those teeth that are not quite in their final positions in the middle of treatment.

Certain spacial relationships should be emphasized so the clinician can make a better choice of square and rectangular wires in his practice. The critical factors of importance in selecting these wires are:

1. The relations of the buccal-lingual, and labial-lingual natural inclinations of the maxillary and mandibular dentitions.
2. The wire's stiffness, its range and torsion slot freedom.

It is estimated that the teeth of the mandibular buccal segment will vary in their buccal-lingual axial inclinations from zero degrees or perpendicular to the mandibular plane to approximately a lingual crown tipping of 10° to the mandibular plane. This natural lingually tipped molar or premolar is in direct contrast to the incisal crown segment that is labially tipped from the estimated zero degrees to 12° labial to the mandibular plane (Fig. 1). There are, of course, exceptions to this generalization; however, they are infrequent in number. Therefore, the usual relative axial relations between the anterior and posterior segments in the mandibular arch are opposite each other. The reason this point is brought forth is that a direct relation exists between the natural dentition's axial inclination and the effectiveness of a square or rectangular wire in producing buccal-lingual, or labial-lingual torque. For the

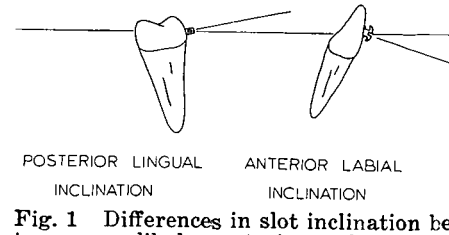

Fig. 1 Differences in slot inclination between mandibular anterior and posterior teeth in the natural dentition.

effectiveness or lack of it is dependent upon the difference between the quantity of torque freedom of the square or rectangular wire and the .022 x .028 slot compared with the difference between the mandibular anterior labially inclined tooth and the mandibular posterior lingually inclined tooth. One can illustrate this concept of torque effectiveness with an example.

An example is the clinical condition where the lower incisor is 95° to the mandibular plane and premolars and molars are lingually inclined 5° in the natural dentition. Any square or rectangular wire aside from one that almost completely fills the slot (or .0215 x .028) and seated in the brackets will exert little or no torque because of the freedom of rotation the smaller square and rectangular wires have when seated in the .022 x .028 slot; i.e., there is from 10° to 31.5° of rotational freedom between the square or rectangular wire and the .022 x .028 slot in a range of wires from .016 x .016 (31.5° freedom) to .018 x .025 (10.0° freedom).

The relative differences in axial inclination of the anterior and posterior teeth in the maxillary arch are similar to the mandibular arch except that the mandibular anteriors are more labially inclined in an absolute sense ($\underline{1}$ to SN = 105 compared with $\bar{1}$ to MP = 92) and the posterior teeth are inclined somewhat less lingually. However, the magnitude of axial differences between the anterior and posterior segments is almost similar to those differences in the mandibular arch. Therefore, the reaction of seating equal square or rectangular wires in the maxillary and mandibular arches will be nearly the same; or there will be more of a final vertical relationship of all the teeth compared to the natural differences in axial inclination found between the anterior and posterior segments if a series of ascending sized wires is used.

Factors Governing the Selection of Square and Rectangular Wires

The wire's performance will differ as a function of its shape and size, and the clinician's selection will depend upon his clinical needs relative to the wire's stiffness, range, or possible torque. The simultaneous interrelations of these three factors are important (Fig. 2). In order that one can visualize these variables, relative tables are shown comparing the square and rectangular wires with a commonly used .016 round leveling archwire. It should be stressed that the comparisons are in relative and not absolute terms, i.e., relative to the performance of empirical "feel" of an .016 round archwire. The relative terms of torque freedom are related to the other square and rectangular archwires in the .022 x .028 slot and hold no relationship to the round wire as far as torque is concerned.

Some Similarities and Differences Between Wires

An .016 square wire has been frequently used in recent times because the property stiffness increases when compared with an .016 round wire while the range of wire activation remains the same as in .016 round wire. One can observe this fact and use the square .016 wire to advantage. This wire is of little value in the .022 x .028 slot since there is 31.5° rotation freedom before the wire exerts any "torque" but the stiffness is 41.1 per cent greater in the .016 square and it has the advantage of having 100 per cent of the range the .016 round wire possesses. This means in situations where one wants considerable range such as in leveling procedures and wants still more force per unit area of his wire (stiffness) in cases where the erupted teeth are banded, yet, because of the patient's eruption age, the clinician has a long-spanned unattached archwire from lateral incisor to molar,

	STIFFNESS(FORCE)	RANGE(DISTANCE)	TORQUE(FREEDOM)
016 x 016 (e)	411% >	SAME-100%	31 5°
(f)	411% >	SAME-100%	31 5°
016 x 022 (e)	774% >	72 7%	18°
(f)	57 3% >	SAME-100%	18°
016 x 025 (e)	84 6% >	64 0%	15.3°
(f)	62 4% >	SAME-100%	15 3°

	STIFFNESS(FORCE)	RANGE(DISTANCE)	TORQUE(FREEDOM)
.017 x 017 (e)	53.8% >	94.1%	21.3°
(f)	53 8% >	94 1%	21.3°
.017 x .022 (e)	78 8% >	72.7%	14.7°
(f)	64.4% >	94.1%	14.7°
.017 x .025 (e)	85 5% >	64.0%	12 6°
(f)	68.7% >	94.1%	12.6°

	STIFFNESS(FORCE)	RANGE(DISTANCE)	TORQUE(FREEDOM)
018 x 018 (e)	63 3% >	88 8%	14 9°
(f)	63 3% >	88 8%	14 9°
018 x 022 (e)	79 9% >	72 7%	11 5°
(f)	70 0% >	88 8%	11 5°
018 x 025 (e)	86 3% >	64 0%	10 0°
(f)	73 6% >	88 8%	10 0°

	STIFFNESS(FORCE)	RANGE(DISTANCE)	TORQUE(FREEDOM)
.021 x .021 (e)	80.2% >	76.1%	2.9°
(f)	80.2% >	76.1%	2.9°
.021 x .025 (e)	88.3% >	64.0%	2.4°
(f)	83.4% >	76.1%	2.4°
.021 x .028 (e)	91.7% >	57.1%	2.1°
(f)	85.2% >	76.1%	2.1°

Fig. 2 Relative comparisons of .016 round and .016, .017, .018, .021 square and rectangular wires; (e) equals the edgewise plane of flexibility and (f) equals the flat plane of flexibility.

he has a wire available that is capable of this kind of performance. In this instance the .016 square and stiffer wire is needed because of the long unattached wire between the cuspid and molar span. Even though there is increased stiffness in the wire, there is considerable range found in the same wire to take out irregularities in the anterior teeth.

Other choices that present themselves are those comparative choices of the relative performance values inherent in the .016 x .016 wire compared with the .017 x .017 wire compared with the .018 x .018 wire. In comparatively selecting these wires, the greatest amount of change occurs in the torsion ability of the .018 square wire compared with the .016 square wire. It has only 14.9° of torque freedom in the .022 x .028 slots, but it still possesses 88.8 per cent of the range found in the .016 round wire. Therefore, this wire can be used in cases where torsion of the wire is needed to finish the leveling before using a wire to fill the bracket slot which will perform almost only in torsion.

When one chooses between the .016 x .016, the .016 x .022, and the .016 x .025; or the .017 x .017, the .017 x .022, and the .017 x .025; or the .018 x .018, the .018 x .022, and the .018 x .025 there are two significant increases from increased thickness of the wire in the "edgewise" plane. As the wire becomes thicker, i.e., .018 to .022 to .025 in the horizontal plane, a much greater ability to "torque" exists in the wire without placing any twist in the wire itself. An example is the difference of torquing ability in the .017 x .017 and the .017 x .025. The change of torque freedom is from 21.3° to 12.6°; therefore, choosing the thickness of the edgewise plane of the wire will alter the torsion effect of uprighting roots a significant amount.

The other significant change found in performance is the inability of the clinician to use a .022 or .025 thick or deep wire for almost any purpose other than torsion, or perhaps a very small amount of vertical tooth movement. In other words, if one doesn't have the rotation corrected and the arch form nearly where he wants it with the round or square wires, he can do little in the horizontal plane to take out rotation be-

cause the wire is so stiff and it is difficult to tie deeply into the bracket slot of the malposed tooth. Most of his range of wire activation is now limited to only the flat plane that is of practical use.

Conclusions

Square and rectangular wires are used primarily for their torsion characteristic, yet .016 x .016, and .017 x .017 square wires are used for their leveling capabilities. The clinician's ability to "torque" teeth with .016 x .016, .017 x .017, and .018 x .018 wires is very limited because of the large degree of freedom between the square wires and the size of the bracket slot; however, .021 x .021, .021 x .025, or .021 x .028 wires are best for "torque" in the .022 x .028 slot.

A large amount of "root uprighting" occurs with a nontwisted .021 x .025 ideal archwire because the axial inclinations of the anterior versus the posterior teeth are in opposite relations; for example, the lower anterior teeth are usually anteriorly inclined while the lower posterior teeth are usually lingually inclined.

The factors governing the selection of square and rectangular wires are their relative stiffness range and torque freedom. The interrelations of these three factors are very important when choosing which wire to use.

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