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Angular Rotation of Rectangular Wire in Rectangular Buccal Tubes

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A Thesis Submitted to the Faculty of the Graduate School of Loyola University in Partial Fulfillment of the Requirements for Degree of Master of Science

February

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DEDICATION

In loving memory of my mother, Alicia.

To my wife, Monica, for her love, devotion and patience.

To my father, Salomon, for offering the greatest support and encouragement throughout my first twenty-three years of life.

ACKNOWLEDGEMENTS

I wish to thank Doctor James L. Sandrick, who as my advisor, offered invaluable guidance and inspiration during the course of this investigation and for allowing the realization of my professional career.

I am especially grateful to Doctor Milton L. Braun, whose continued guidance and enthusiasm have provided me with sincere appreciation of clinical and investigative principles.

I also wish to express my appreciation to Doctor Lewis Klapper, for his assistance and sincere encouragement.

AUTOBIOGRAPHY

Eliezer Raphael was born on April 17, 1954 in Mexico D.F., Mexico to Solomon Raphael and Alicia Pardo, being the first of five children.

In 1972, he graduated from Colegio Columbia. He began his formal dental studies at the Universidad Tecnologica de Mexico in 1972 and graduated in 1976 with a Doctor of Dental Surgery degree.

His graduate studies began in the Department of Orthodontics, Loyola University School of Dentistry, in 1976 under Doctor Milton L. Braun, Chairman.

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CHAPTER I

INTRODUCTION

Since Doctor E. H. Angle created the edgewise appliance, his last and greatest contribution to orthodontics, three cornerstones of modern edgewise orthodontics were created:

1. Ability to obtain tooth movements in all three planes of space with a single archwire.[4]

2. The philosopy of treating to an ideal arch or to Angle's concept of the "line of occlusion".[4]

3. The use of rectangular or square edgewise arches, which, if properly used, control arch width, form, buccolingual crown inclinations, and incisor crown and root torque.[4]

Buccal tubes have been used for more than a century to obtain molar control.

Although there is an abundance of material on the edgewise mechanism, virtually all of it pertains to diagnostic and clinical procedures. Very little has been written about the buccal tube and its importance as a means of molar stabilization and mechanical control.

The purpose of this investigation is to measure and determine the amount of rotation of rectangular wires within rectangular buccal tubes and to use this data as a means for making clinical judgments.

CHAPTER II

REVIEW OF LITERATURE

Molar Control and Attachments

Since the molar is the last tooth in the arch, it is subjected to resultant forces exerted to other teeth in the arch. These forces cover a wide range of tooth movements. As the widest and largest tooth in the mouth it is difficult to move it without affecting the adjacent teeth. That is why, management of these forces lies entirely on the selection of attachments that will govern many actions throughout treatment.[3]

A wide variety of attachments are available for molar control.

Buccal Tube

This is the basic molar attachment of the edgewise appliance. The original tube was a piece of 0.022 by 0.028 inch gold or nickel silver tubing that was soldered to the molar band.[1-2]

The reason that the edgewise mechanism employs the buccal tube in the molar tooth, is that it is used for treatment and stabilization of the arch wire.[2] Therefore it is a completely encased attachment, instead of the regular edgewise bracket used in the remaining teeth of the arches.

Tube Length

If adequate control over tipping and rotation is of extreme importance, then tube length has to be taken in consideration.[3]

The longer the tube the better control over these movements, but since there is a limited space between attachments on either side of the molar, the control in tipping and rotation is directly proportional to the tube length.[3]

If a distal projection is used, it must provide clearance for insertion of elastics and ligature wire.[3]

Tube Types

Actually, there are three basic types of buccal tubes available.

1. Mandrel formed - the tube is pressed and machine-folded to the required size.

2. Drilled formed - the tube is machine-formed and drilled to the size.

3. Cast formed - the latest available, this tube is formed in a mold.

Torque and Torsion

In orthodontics the word "torque" has been used in describing the effect on a tooth of the force delivered by a twisted (Torqued) wire.[3]

Often, confused terminologies, Torque and Torsion are used to describe the twist of a wire. In science, Torque is the force (stress that causes the twist). Torsion is the actual twisting that results from Torque.[3]

Lumen Size and Torque Control

If torque control with rectangular wire is needed, the wire has to have a close engagement with the tube lumen.

A 1-mil (0.001 inches) freedom of the wire in the lumen (when 1 mil narrower than lumen) will give from 2^{o} - 4^{o} of freedom in tipping in the direction of torque applied.[3]

A freedom of 5^{o} will be a result of a 2-mil difference.

Clinically, for torque control, the wire should be kept within 2 mils of the lumen size.[3]

An important clinical consideration in torque action is when individual teeth need this type of movement. Wires that fit too precisely in the lumen should never be used to torque them.[3] When the Torqued Wire is inserted into the tube, the twist of the wire will tip the adjacent tooth in the opposite direction.[3] If the wire is left long enough so it can return to its passive state, the adjacent tooth will not be permanently moved, but that tooth will have been subjected to an unnecessary back-and-forth action.[3] If the need calls for an individual torqued tooth, the wire should be sufficiently undersized to allow the torqued wire to rotate in the slot of the adjacent tooth without any torque action in the latter.[3]

CHAPTER III

METHODS AND MATERIALS

This study involved rectangular and square wires and rectangular buccal tubes.

The samples included four wires, two which are used when the lumen size is .018 x .025 inches and the other two when the lumen size is .022 x .028 inches. (inches = x") The ones used in the .018 x .025 inches lumen size are:

1. .016 x .016" square wire
2. .016 x .022" rectangular wire

The wires used when the .022 x .028" lumen size is employed are:

1. .018 x .022" rectangular wire
2. .019 x .026" rectangular wire

The rectangular tubes that were used for the experiment are:

1. .018 x .025" lumen size
2. .022 x .028" lumen size

Three basic types of tubes were used:

1. Mandrel formed
2. Drilled formed
3. Cast formed

The tubes were provided by three Orthodontic companies: Unitek*, Rocky Mountain** and ORMCO***. All three types of tubes were tested so the lack of quality in this area could be determined.

* Unitek Corporation, 2724 S. Peck Road, Monrovia, California 91016
** Rocky Mountain Corporation, P.O. Box 17085, Denver, Colorado 80217
*** Ormco Corporation, 1332 S. Lone Hill Avenue, Glendora, California 91740

The Unitron (model N) metallographic microscope was used and a Nikon adjustable rotating stage was adapted so it could be mounted on the microscope. An adjustable vise was designed and later fabricated so it could hold and position the rectangular tubes in the center of the rotatable stage and fastened to the latter with adjustable screws, used to center the holding vise on to the rotatable stage. (Figure 1). A spring loaded pin vise was also designed so it could hold the four (4) rectangular wires. It was mounted on the upper part of the microscope, and with the aid of two adjusting screws the wire could be centered in the lumen of the tube and maintain it as close as possible to the center of rotation of the rotatable stage (Figure 2). Having the tube and wire at the microscope's center of rotation, the stage was then moved clockwise and counterclockwise until the wire would engage or bind inside the tube's lumen. When the "binding" occured, the rotation was recorded in degrees making six readings (six counter clockwise and six clockwise). The experiment tested all the tubes that were provided by the three companies.

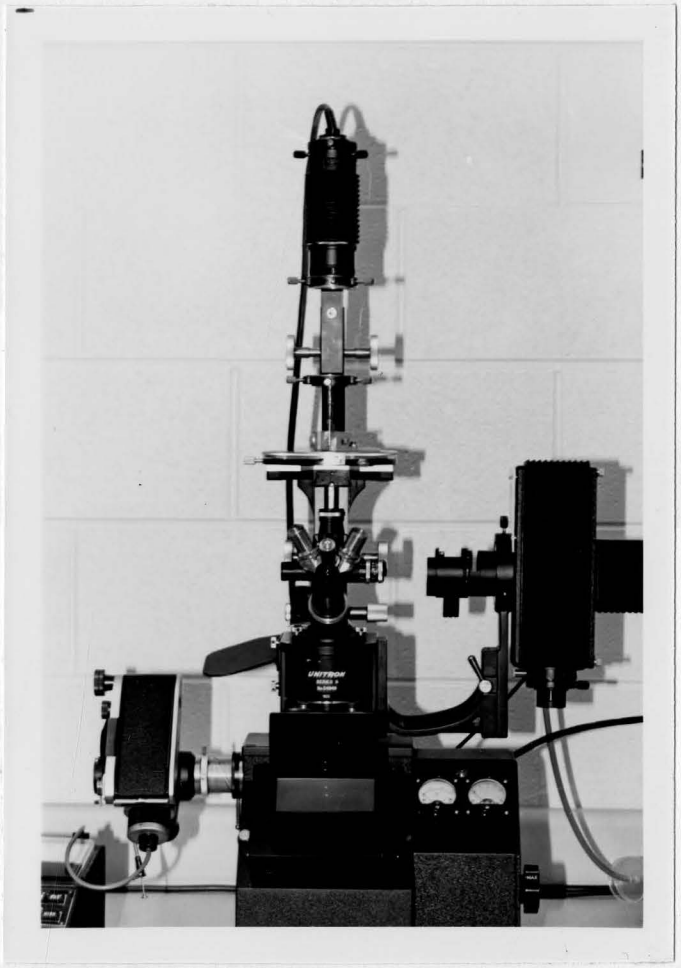


Figure 1. Unitron Metallographic Microscope

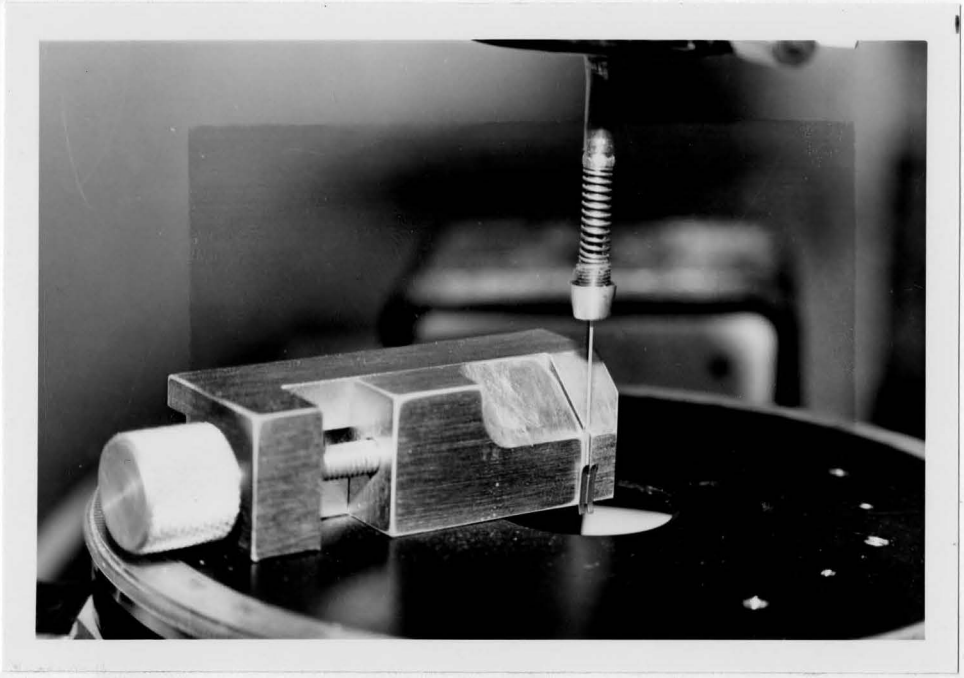
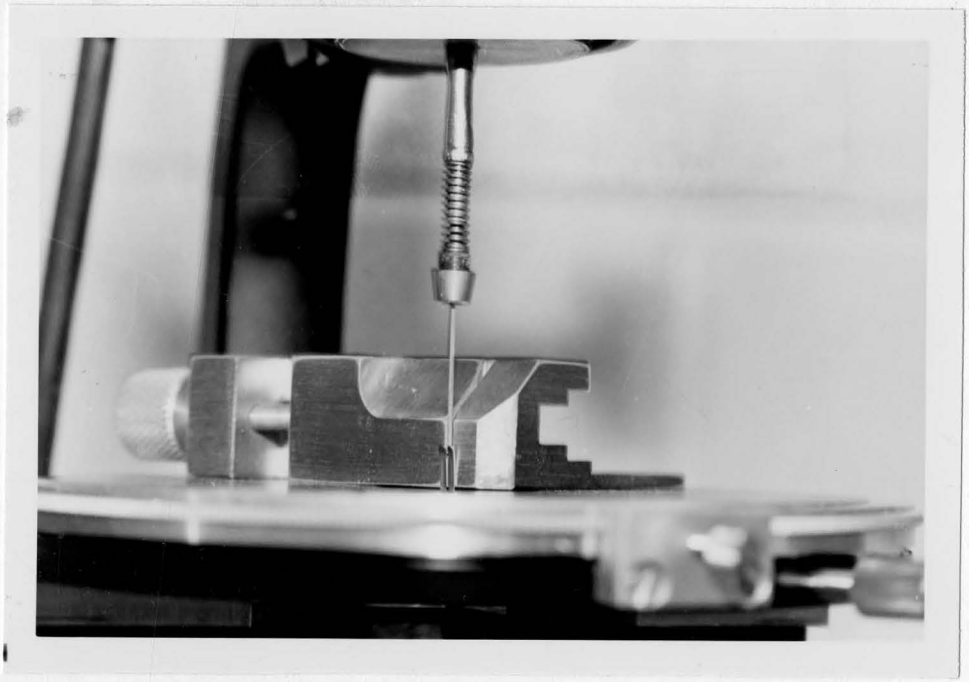


Figure 2. Holding Vise Mounted to the Rotatable Stage



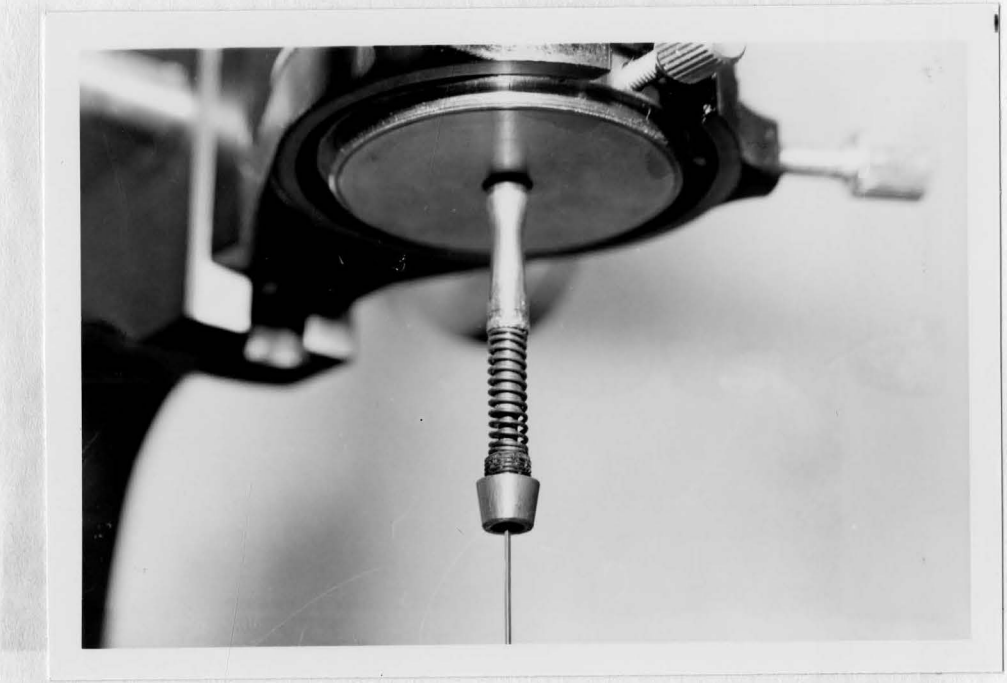


Figure 3. Spring loaded wire holding vise.

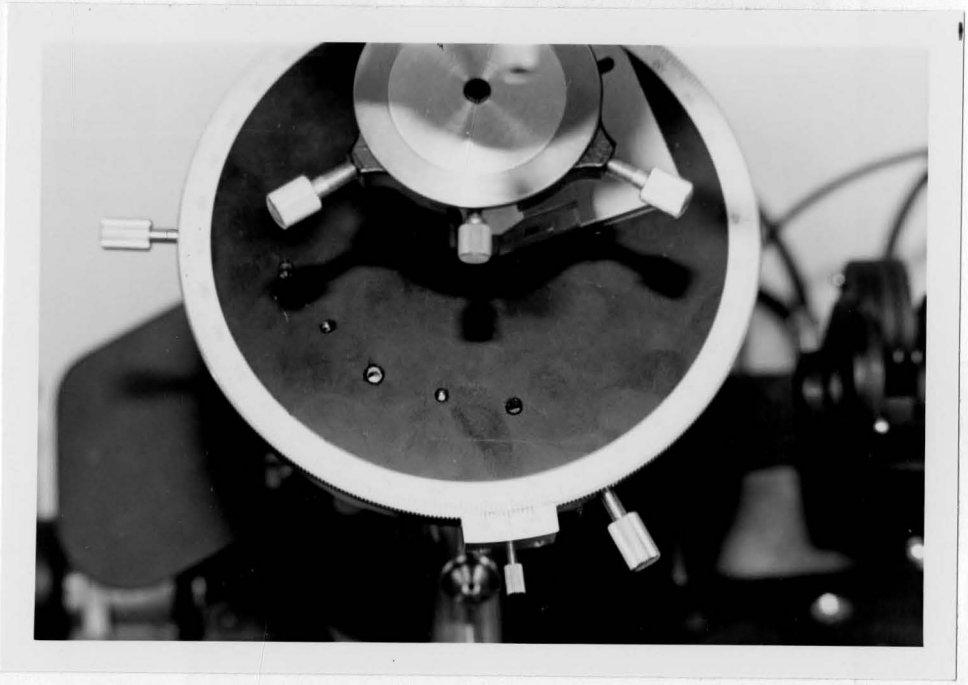


Figure 4. Rotatable Stage.

Figure 5. Upper view of tube holding vise mounted on the stage.

Figure 6. Side view of microscope's light source.

RESULTS

The results of the tube measurements on the metallographic microscope are presented in the following five tables. Each manufacturer is indicated in the first column. In the second column, the wire's size used is shown. The third column shows the mean of the clockwise and counterclockwise rotation. The fourth column shows the standard deviations for the two measurements. Finally, the column at the far right, the range, showing the highest and lowest rotation found in the six measurements (clockwise and counterclockwise) made on the five tubes.

When a .016 x .016" wire was used in Ormco's .018 x .025" drilled tubes, it was noted (Table 1) that it rotated from 360^{o} (no bind) to 90^{o} (bind). If the three manufacturers are compared (Table 1), none of the tubes, when using a .016 x .016" wire, binded.

Table 2 denotes that the mandrel tubes made by the three manufacturers, when .016 x .016" wire was inserted, only Ormco's tubes engaged with a mean of 20.05^{o} (clockwise) and 19.87^{o} (counterclockwise).

Table 4 shows that Unitek's 0.022 x 0.028 mandrel formed tubes' lumen was too small for the .019 x .026" wire.

Results of the measurements of lumen size on the different types of buccal tubes are listed on tables 6 and 7.

Table 6 indicates that Rocky Mountain 0.018 x 0.025" drilled tubes actually had a 0.0216 x 0.0264" (lumen size as measured).

Of the three manufacturers, Unitek's drilled tubes (0.018 x 0.025") were the closest to the lumen size as specified, that is to say, they measured 0.0189 x 0.0277".

Table 8 shows the actual measurements conducted on the four different wires that were used in this project. The 0.018 x 0.022" wire was actually 0.0177 x 0.0228", and the 0.0154 x 0.0217" measurement obtained was that of the 0.016 x 0.022" wire.

TABLE I

Degree of Angular Rotation of Square and Rectangular Wire in .018 x .025 inch Drilled Tubes

Tube Manufacturer	Wire Size Inches	Degrees Rotation Mean ± S.D.	Range Degrees
Ormco	.016 x .016	--- --- cw*	90 - 360
		--- --- ccw*	90.5 - 360
	.016 x .022	13.75 ± 3.18 cw*	9.3 - 19.6
		11.97 ± 2.88 ccw*	8 - 18.5
Unitek	.016 x .016	--- --- cw*	92.7 - 360
		--- --- ccw*	100 - 360
	.016 x .022	10.80 ± 3.64	5 - 16.8
		9.62 ± 4.48	4.5 - 16.5
Rocky Mountain	.016 x .016	--- --- cw*	360
		--- --- ccw*	360
	.016 x .022	19.41 ± 3.26	14 - 23.9
		20.20 ± 3.67	16 - 31.1

* cw - clockwise
* ccw - counter clockwise
N.B. - Blank space signifies 360° rotation without binding.

TABLE II

Degree of Angular Rotation of Square and Rectangular Wire in .018 x .025 inch Mandrel Formed Tubes

Tube Manufacturer	Wire Size Inches	Degrees Rotation Mean ± S.D.	Range Degrees
Ormco	.016 x .016	20.05 ± 4.38 cw*	14.7 - 26
		19.87 ± 4.95 ccw*	12 - 27
	.016 x .022	12.33 ± 1.64 cw*	9 - 16
		11.46 ± 1.97 ccw*	8 - 16
Unitek	.016 x .016	--- --- cw*	50 - 360
		--- --- ccw*	60 - 360
	.016 x .022	--- --- cw*	43 - 360
		--- --- ccw*	29.5 - 360
Rocky Mountain	.016 x .016	--- --- cw*	+100 - 360
		--- --- ccw*	+100 - 360

*cw - clockwise
*ccw - counter clockwise
N.B. - A blank space signifies 360° rotation without binding

TABLE III

Degree of Angular Rotation of Rectangular Wire
in .022 x .028 inch Drilled Tubes

Tube Manufacturer	Wire Size Inches	Degrees Rotation Mean ± S.D.	Range Degrees
Ormco	.018 x .022	--- --- cw*	14 - 360
		--- --- ccw*	14 - 360
	.019 x .026	22.10 ± 11.29 cw*	.5 - 35
		29.15 ± 14.58 ccw*	.6 - 40.5
Unitek	.018 x .022	--- --- cw*	+100 - 360
		--- --- ccw*	+100 - 360
	.019 x .026	24.86 ± 6.04 cw*	16.5 - 37
		32.56 ± 5.46 ccw*	22 - 39
Rocky Mountain	.018 x .022	--- --- cw*	360
		--- --- ccw*	360
	.019 x .026	32.51 ± 4.38 cw*	28 - 42
		38.98 ± 6.27 ccw*	31 - 51

* cw - clockwise
*ccw - counter clockwise
N.B. - Blank space signifies 360° rotation without binding

TABLE IV

Degree of Angular Rotation of Rectangular Wire
in .022 x .028 Mandrel Formed Tubes

Tube Manufacturer	Wire Size Inches	Degrees Rotation Mean ± S.D.	Range Degrees
Ormco	.018 x .022	24.03 ± 1.39 cw*	20.5 - 25.5
		23.6 ± 2.57 ccw*	21 - 30
	.019 x .026	12.63 ± 1.66 cw*	11 - 16
		16.48 ± 1.71 ccw*	13 - 20
Unitek	.018 x .022	13.1 ± 5.52 cw*	7 - 25
		8.85 ± 3.78 ccw*	3 - 16
	.019 x .026	--- --- **	0 - 2
		--- --- **	0 - 3.5
Rocky Mountain	.018 x .022	25.41 ± 3.84 cw*	21 - 33.5
		25.78 ± 2.57 ccw*	22 - 30
	,019 x .026	12.48 ± 2.18 cw*	8.5 - 16
		18.5 ± 3.77 ccw*	11 - 26

* CW - clockwise
*ccw - counter clockwise
**N.B.- A blank space signifies no fit (0^{o}) rotation.

TABLE V

Degree of Angular Rotation of Square and Rectangular Wire in .018 x .025 and .022 and .028 inch Cast Tubes

Tube Manufacturer	Wire Size Inches	Degrees Rotation Mean ± S.D.	Range Degrees
Unitek	.016 x .016	21.62 ± 4.63 cw*	11 - 28.5
		23.14 ± 5.66 ccw*	13.5 - 33
	.016 x .022	12.82 ± 2.23 cw*	9 - 17
		10.83 ± 1.69 ccw*	6.5 - 14.5
Tube .022 x .028 lumen	.018 x .022	26.70 ± 2.93 cw*	21.5 - 32
		24.85 ± 3.26 ccw*	19 - 29.5
	.019 x .026	12.71 ± 1.48 cw*	10 - 15.5
		18.58 ± .93 ccw*	17 - 20

* cw - clockwise
*ccw - counter clockwise

TABLE VI

Measurements of Lumen Size on the Different Types of Buccal Tubes

BRACKET	TYPE	LUMEN SIZE (as specified)	LUMEN SIZE (as measured) WIDTH (inches)	LENGTH (inches)
Ormco	Drilled	0.018 x .025"	0.0209 ± .075	0.0275 ± .014
Unitek	Drilled	0.018 x .025"	0.0189 ± .030	0.0277 ± .043
Rocky Mountain	Drilled	0.018 x .025"	0.0216 ± 0.84	0.0264 ± .079
Ormco	Mandrel	0.018 x .025"	0.0211 ± .016* 0.020 ± .033**	.0289 ± .037
Unitek	Mandrel	0.018 x .025"	0.0246 ± .058	0.0334 ± .033
Rocky Mountain	Mandrel	0.018 x .025"	0.028 ± .023* 0.0207 ± .030**	0.0299 ± .054
Unitek	Cast	0.018 x .025"	0.0188 ± .024	0.0283 ± .030

* Maximum width found, since a rectangular form was not observed.
** Minimum width found.

TABLE VII

Measurements of Lumen Size on the Different Types of Buccal Tubes

BRACKET Manufacturer	TYPE	LUMEN SIZE (as specified)	LUMEN SIZE (as measured) WIDTH (inches)	LENGTH
Ormco	Drilled	0.022 x .028"	0.0229 ± .058	0.0289 ± .035
Unitek	Drilled	0.022 x .028"	0.0254 ± .071	0.0322 ± .042
Rocky Mountain	Drilled	0.022 x .028"	0.0248 ± .01	0.0307 ± .014
Ormco	Mandrel	0.022 x .028"	0.0229 ± .01	0.0303 ± .017
Unitek	Mandrel	0.022 x .028"	0.022 ± .027* 0.0207 ± .021**	0.0329 ± .022
Rocky Mountain	Mandrel	0.022 x .028"	0.0239 ± .01	0.0316 ± .015
Unitek	Cast	0.022 x .028"	0.0226 ± .016	0.0307 ± .02

* Maximum width found, since a rectangular form was not observed.
**Minimum width found.

TABLE VIII

Measurements of the Different Wire Sizes
Used in the Research

		MEASURED (inches)
1.	0.018 x .022"	0.0177 x 0.0228"
2.	0.016 x .016"	0.0161 x 0.0161"
3.	0.019 x .026"	0.0193 x 0.0256"
4.	0.016 x .022"	0.0154 x 0.0217"

DISCUSSION

Specifically, this research project was conducted to determine the accuracy of fit between arch wires and buccal tubes.

Difficulties were encountered in the way the tubes and wires were centered, first to each other, and then to the rotatable stage that was adapted to fit the microscope. The precision and ability to mount the tube at the center of the stage, gave almost equal movements in either the clock and counter clockwise movements.

The subjects submitted to this study, thus being manufacured under the same method, always exhibited different lumen size and form, regardless of being of the same group (that is to say, drilled or mandrel).

It was noted in Table 1, that when a .016 x .016" wire was inserted in a Ormco's .018 x .025" drilled tube, the wire rotated 360^{o} in three of the tubes and binded in 90^{o} in the other two. It is obvious, that a lack of quality in the fabrication of the tubes exists.

In the .018 x .025" formed tubes, Ormco was the best company to provide a tube that cound bind either with a .016 x .016" or .016 x .022" wire (Table 2). If a comparison is made between Ormco and Rocky Mountain when a .016 x .022" is inserted, Ormco's tubes binded at 12.33^{o} (clockwise) and 11.46^{o} (counter clockwise). Not so with Rocky Mountain's tubes which engaged the wire at 16.09^{o} (clockwise) and 14.97^{o} (counterclockwise).

In Table 5, the only Cast tubes tested were from Unitek, because when the research was started this company was the only one fabricating them. It was said that cast tubes were the latest and most accurate to provide the

closest fit between lumen size and wire, which proved not to be the case.

When .016 x .016" wire was used with the Unitek's .018 x .025" lumen size Cast tubes, the mean found was 21.62° (clockwise) and 23.14° (counter clockwise). Table 1 shows that Ormco's .018 x .025" drilled tubes were found to be better machined, having a mean of 20.05° (clockwise) and 19.87° (counter clockwise).

The question now arises: How do the different measurements obtained from the tubes, clinically affect the behavior of the molar control and movement?

It was stated before that for every 0.001 of freedom the wire had inside the tube (when 0.001 inches narrower than lumen), a 2-4° of freedom in typing will occur in the direction of the "torque" applied.[2] A freedom of 5° will be a result of a 0.002" difference. Clinically, the wire should be kept within 0.002" of the lumen size.[3]

Table 1 showed that when a .016 x .016" wire was inserted in a Ormco's .018 x .025" drilled tube, the wire spun 360° in three of the tubes, meaning that no matter how much the wire is "torqued", it will not bind. Clinically, the lower first molars have to be torqued from 30°-35°. To actually deliver 30° torque to those teeth, the wire should be bent 30° in the direction desired. When a Unitek .022 x .028" Cast tubes are used and a .018 x .022" wire is inserted, the mean rotation was found to be of 25.41° (clockwise).

To clinically deliver 30° to the molar, the .018 x .022" should be bent 55.41 to compensate for the 25.41° that the wire needs to engage inside the tube.

Measurements were then taken of all the types of tubes used in the experiment. Surprisingly, not even one of the seventy tubes employed in this research, matched the manufacturer's specified lumen size. Each tube was measured, width and lengthwise. Problems were encountered when Ormco and Rocky Mountain's mandrel tubes were measured. Instead of having a rectangular form, they were "egg" shaped, therefore a maximum and minimum width measurements were conducted.

As stated before, for every 0.002" difference that exists between the wire and the tube lumen's size a 5^{o} of freedom will then occur. Unitek's mandrel 0.018 x 0.025" tube, when measured, actually had a 0.0246 x 0.0334" lumen size. A 0.006" (width) and 0.008" (length) difference exists.

The edgewise archwire gives the orthodontist the potential to control teeth in the three planes of space. Torque is labial or lingual root movement, with the center of rotation at the wire and bracket.

A problem evolves when "torquing" the upper anterior teeth and its effect on the molars (counter torque).[5-6] Usually, retraction of maxillary anterior teeth in a four premolar extraction case, is carried out by means of a closing loop rectangular archwire. Assuming anterior lingual torque is most generally needed, the majority of orthodontists countertorque that movement by placing buccal root torque on the molars. By doing so, it supports the anterior torque and provides the proper torque to the molars.

It was demonstrated that the samples tested on this research all had a loosness of fit that existed between the wire and the buccal tube. If anterior torque is being supported by the molar countertorque and such degree of freedom occurs, eventually the anterior teeth will lose control and insufficient lingual torque will result as space is being closed.

By making this research, it was the intention of the author, to call the attention of the practicing orthodontist to the discrepancies that exist in the manufacturer's specifications, which are an indication of the degree of quality in this field.

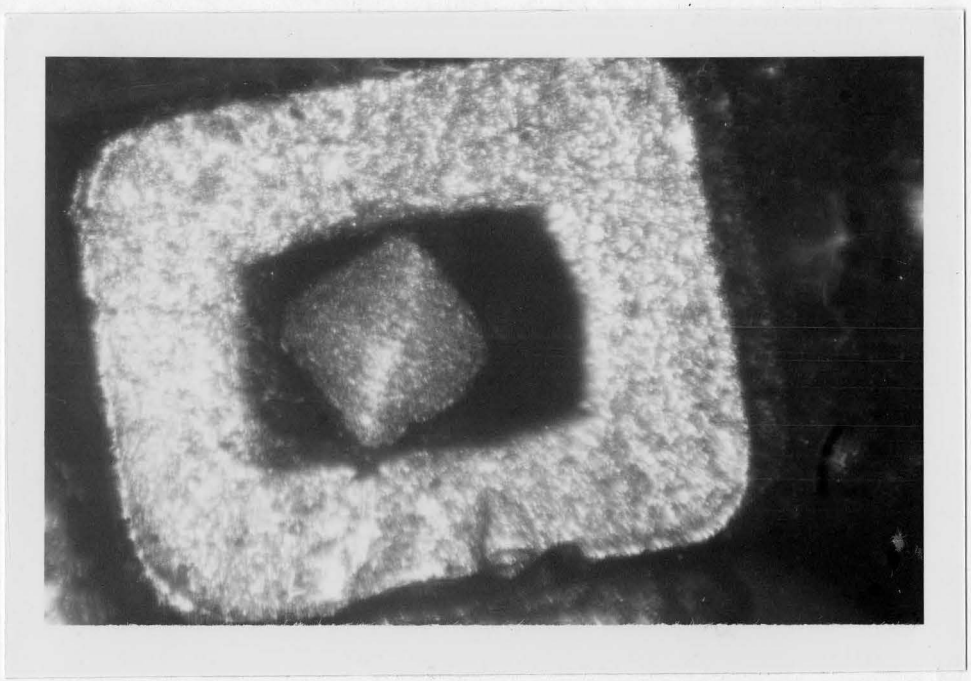


Figure 7. Ormco Drilled 0.018 x 0.025" tube
0.016 x 0.016" wire

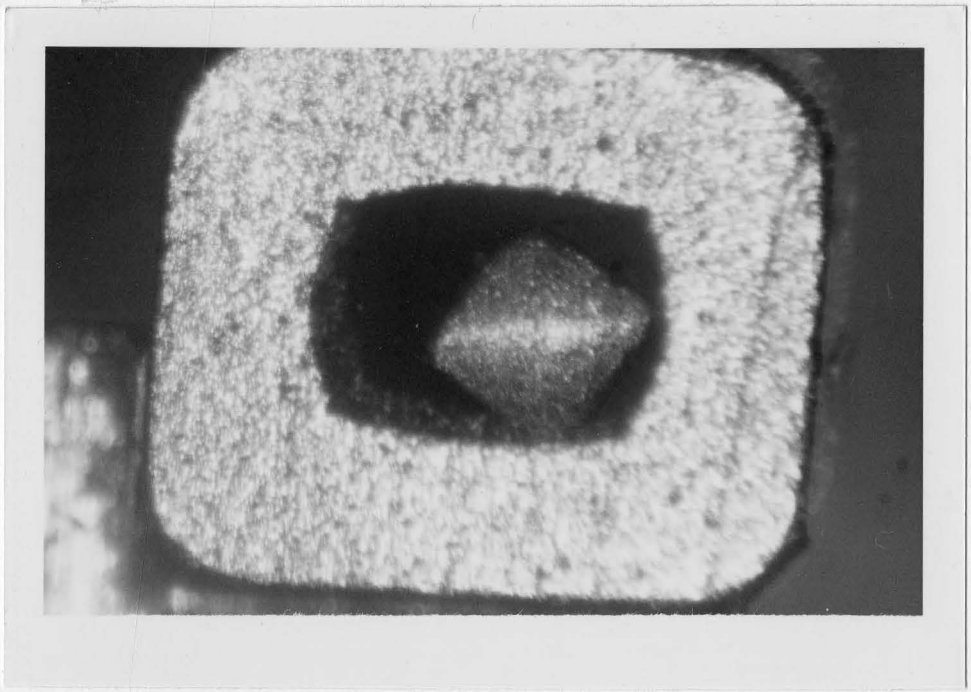


Figure 8. Rocky Mountain Drilled 0.018 x 0.025" tube
0.016 x 0.016" wire

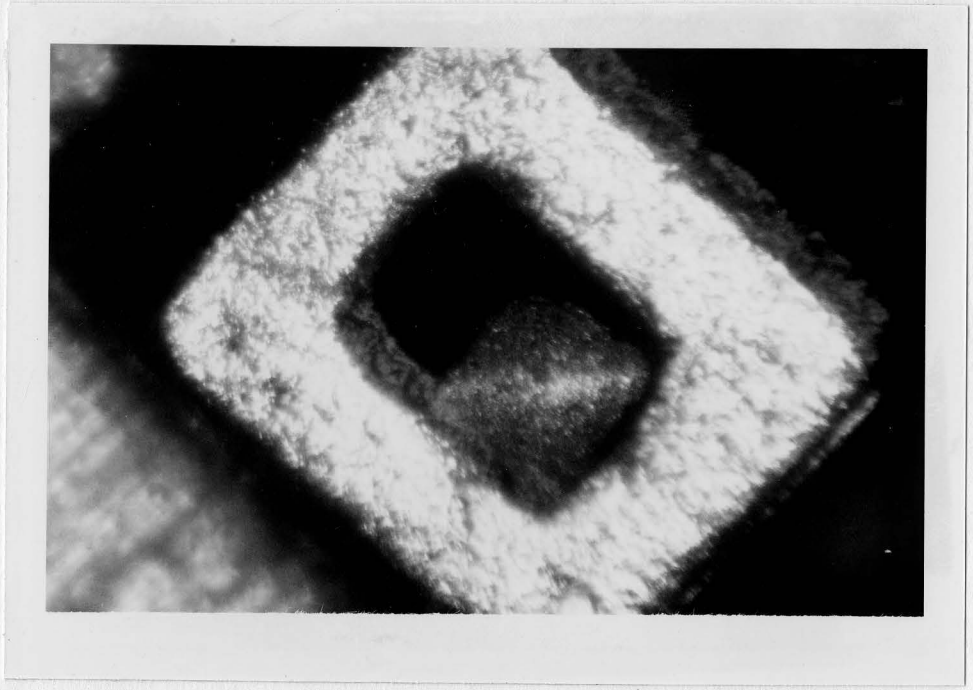


Figure 9. Unitek Drilled 0.018 x 0.025" tube
0.016 x 0.016" wire

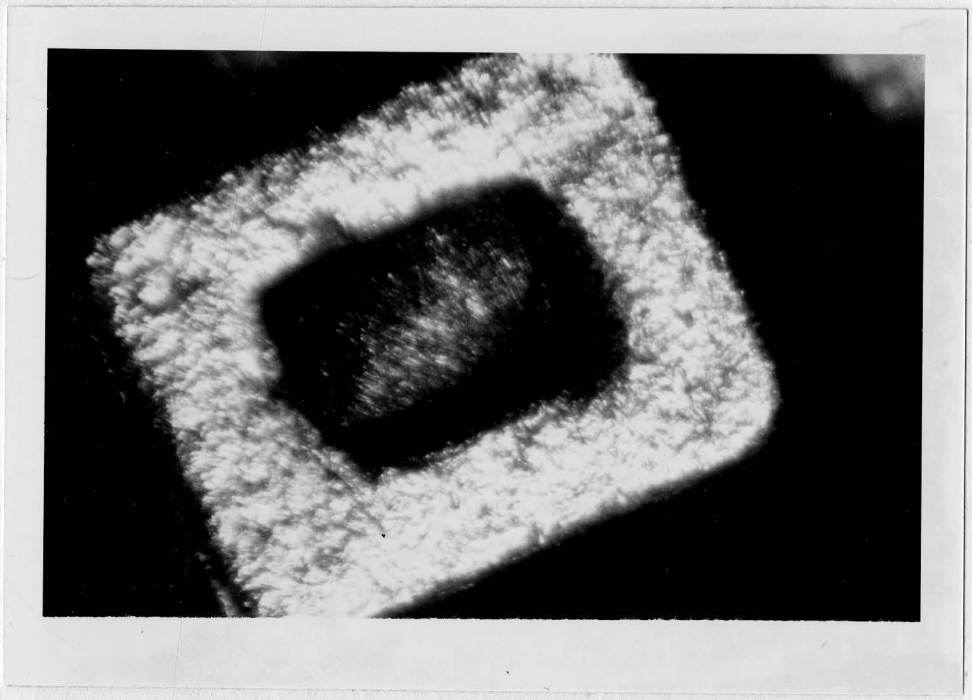


Figure 10. Unitek Drilled 0.018 x 0.025" tube
0.016 x 0.022" wire

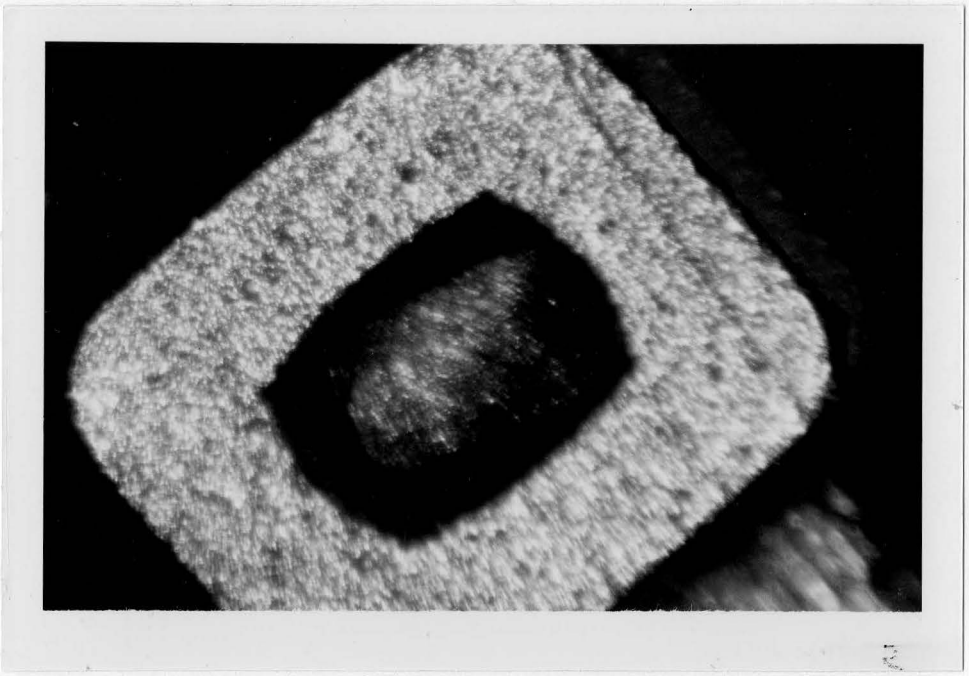


Figure 11. Rocky Mountain Drilled 0.018 x 0.025" tube
0.016 x 0.022" wire

Figure 12. Rocky Mountain Mandrel 0.018 x 0.025" tube
0.016 x 0.022" wire

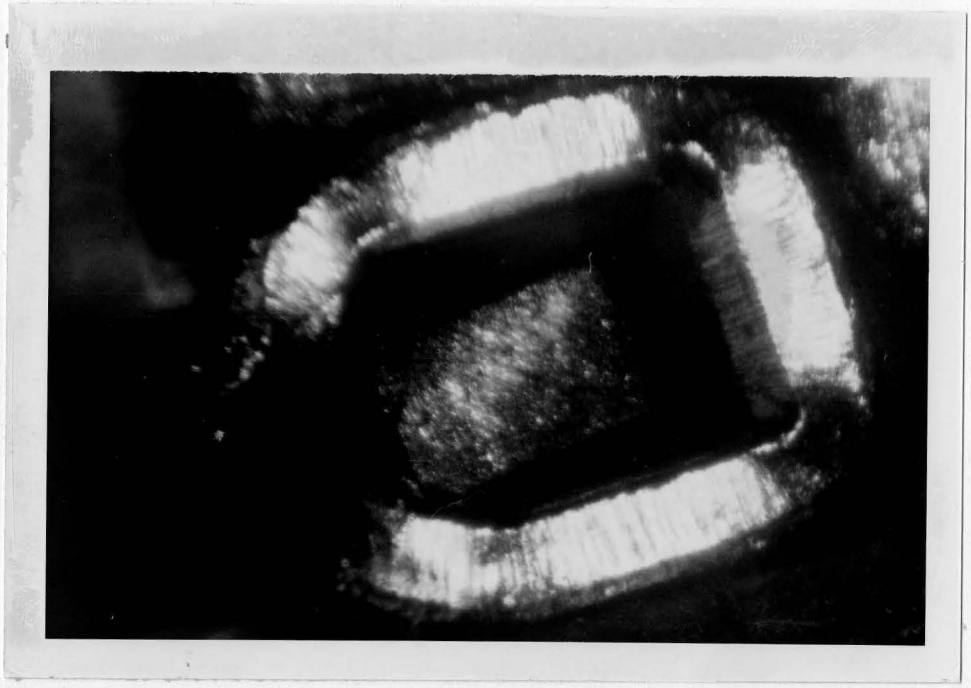


Figure 13. Unitek Mandrel 0.018 x 0.025" tube
0.016 x 0.022" wire

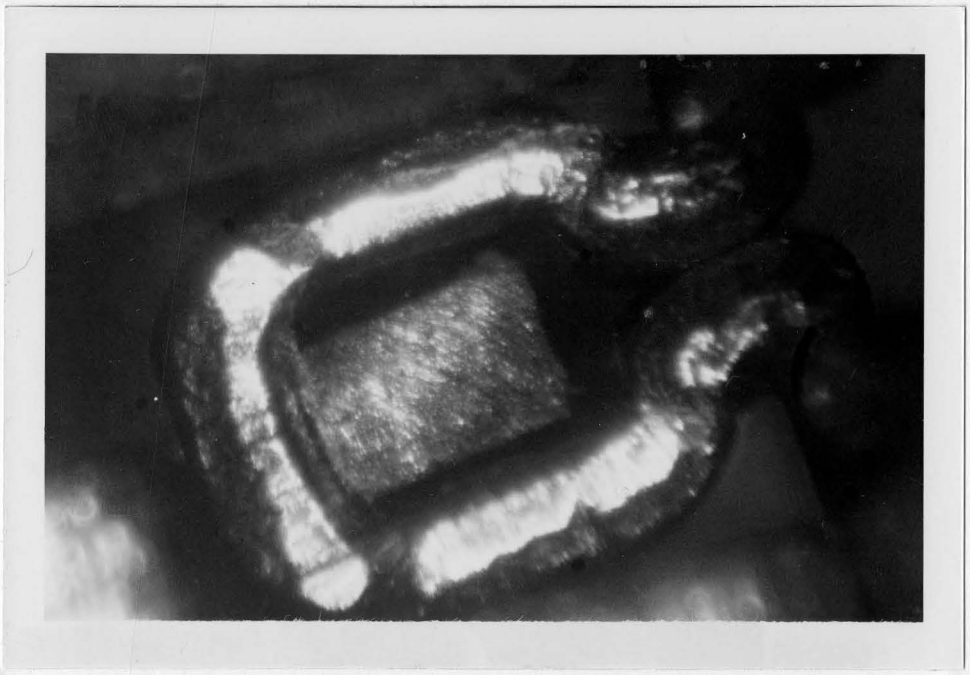


Figure 14. Ormco Mandrel 0.018 x 0.025" tube
0.016 x 0.022" wire

Figure 15. Ormco Mandrel 0.018 x 0.025" tube
0.016 x 0.016" wire

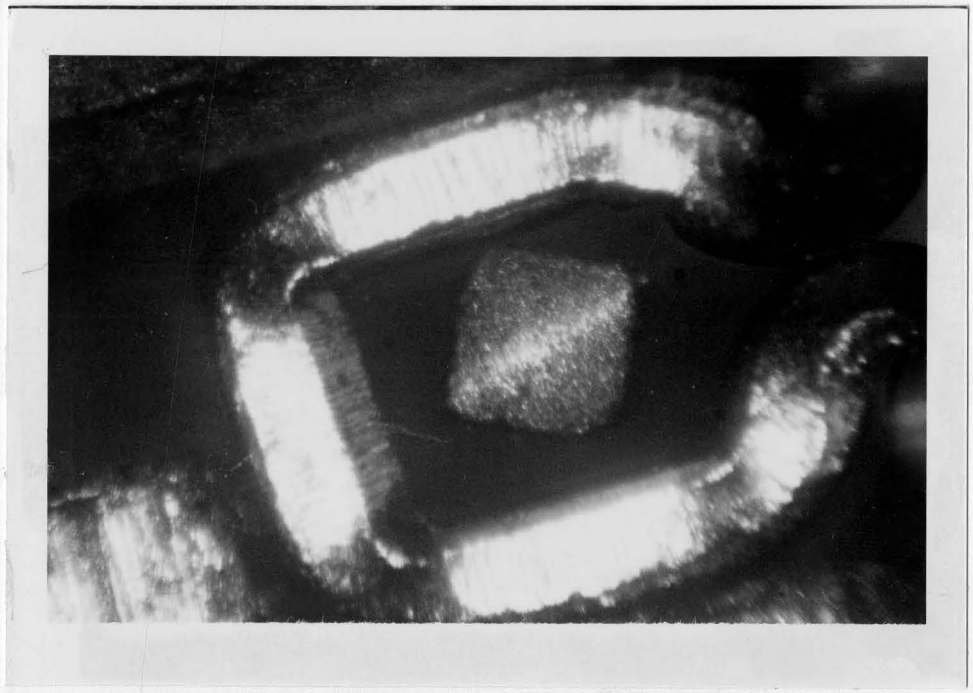


Figure 16. Unitek Mandrel 0.018 x 0.025" tube
0.016 x 0.016" wire

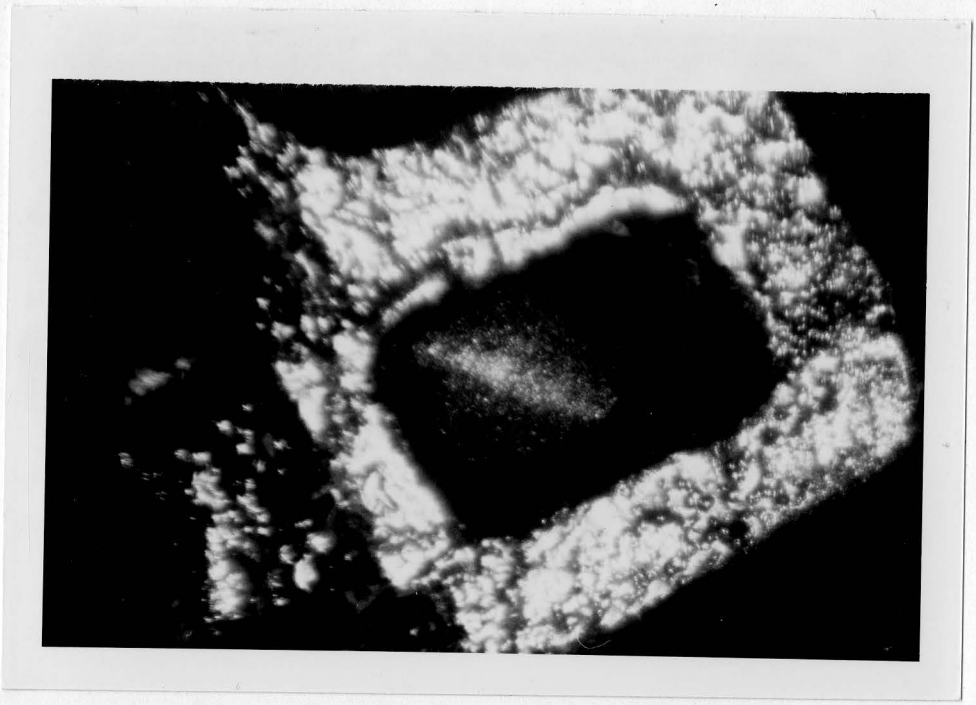


Figure 17. Unitek Cast 0.018 x 0.025" tube
0.016 x 0.016" wire

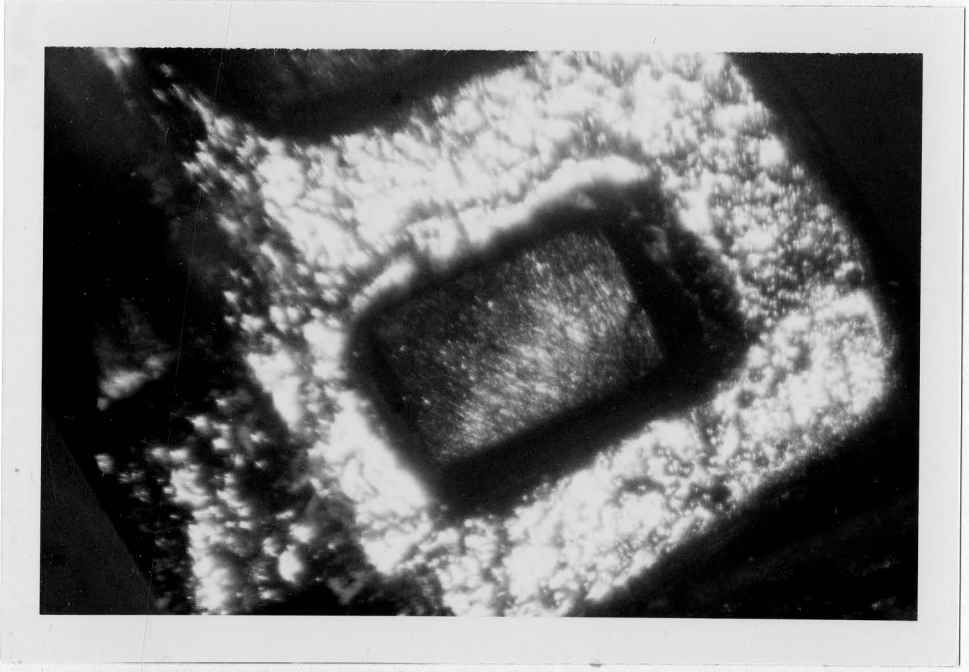


Figure 18. Unitek Cast 0.018 x 0.025" tube
0.016 x 0.022" wire

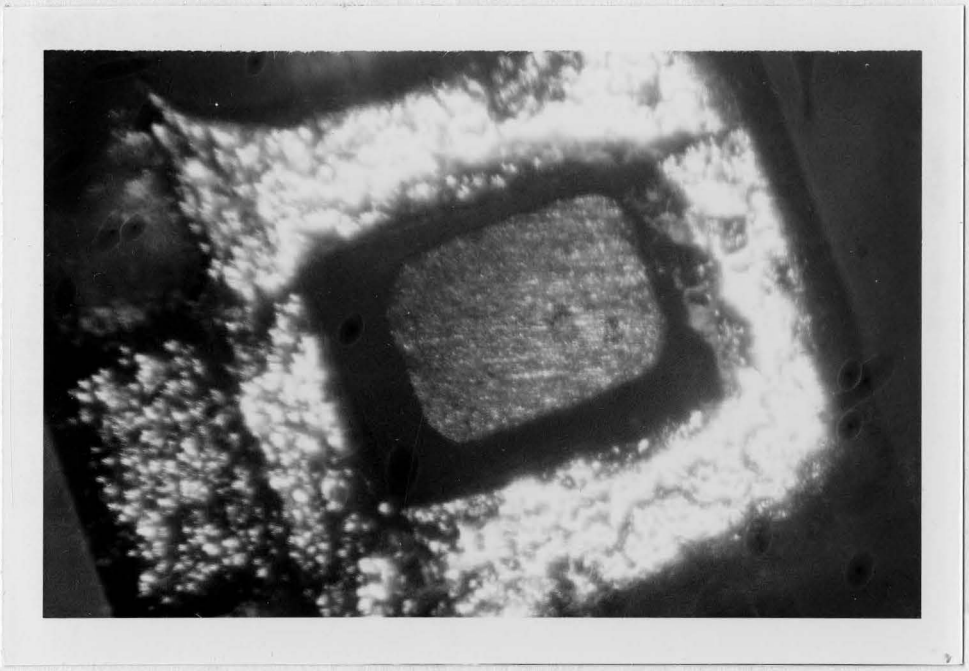


Figure 19. Unitek Cast 0.022 x 0.028" tube
0.018 x 0.022" wire

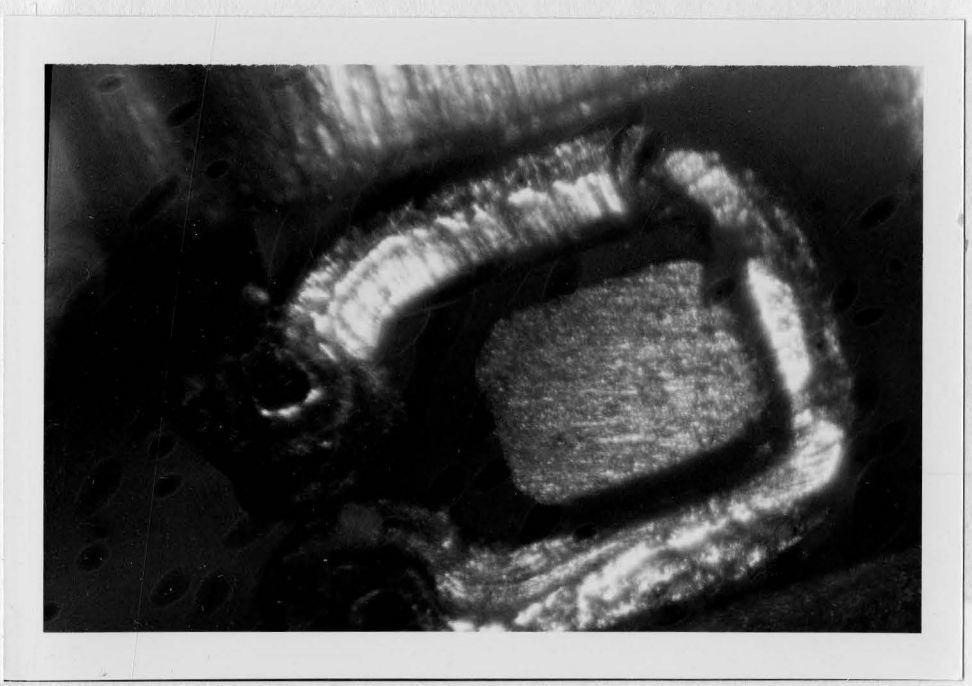


Figure 20. Ormco Mandrel 0.022 x 0.028" tube
0.018 x 0.022" wire

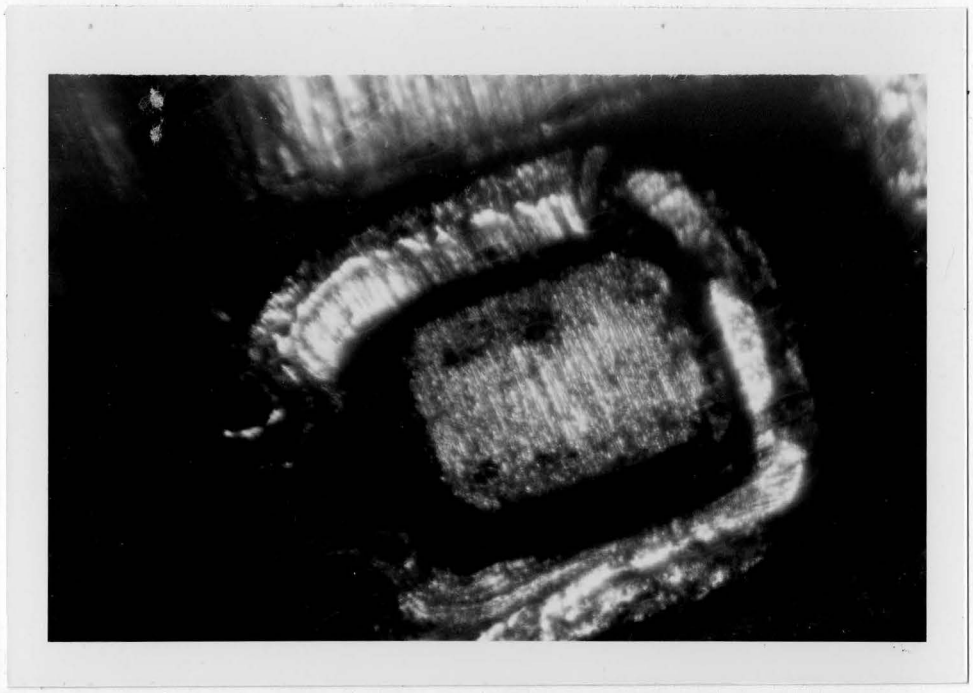


Figure 21. Ormco Mandrel 0.022 x 0.028" tube
0.019 x 0.026" wire

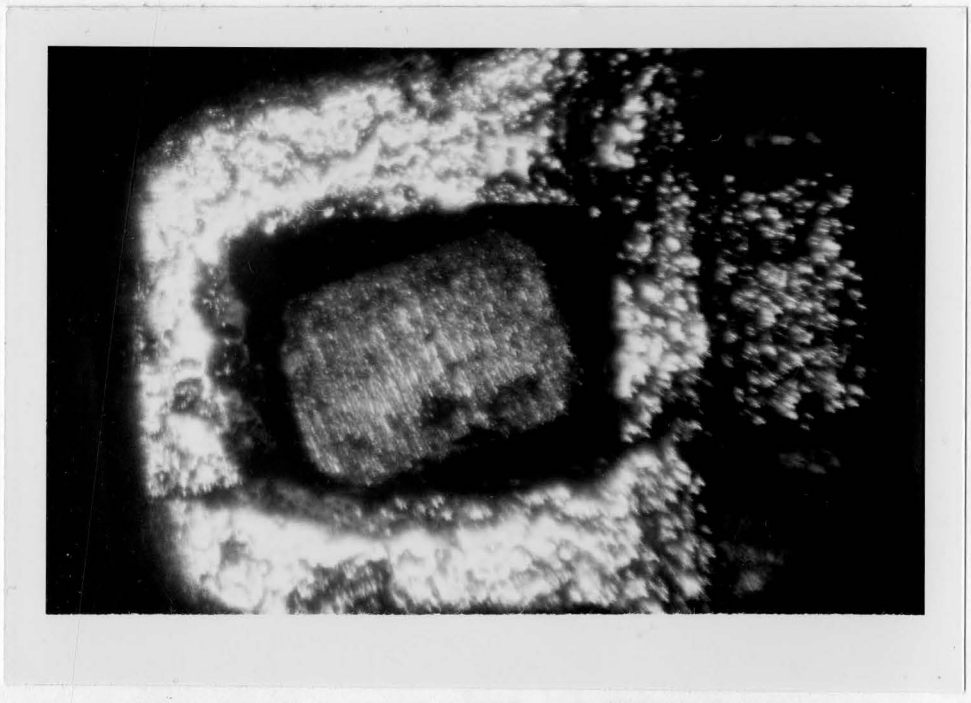


Figure 22. Unitek Cast 0.022 x 0.028" tube
0.019 x 0.026" wire

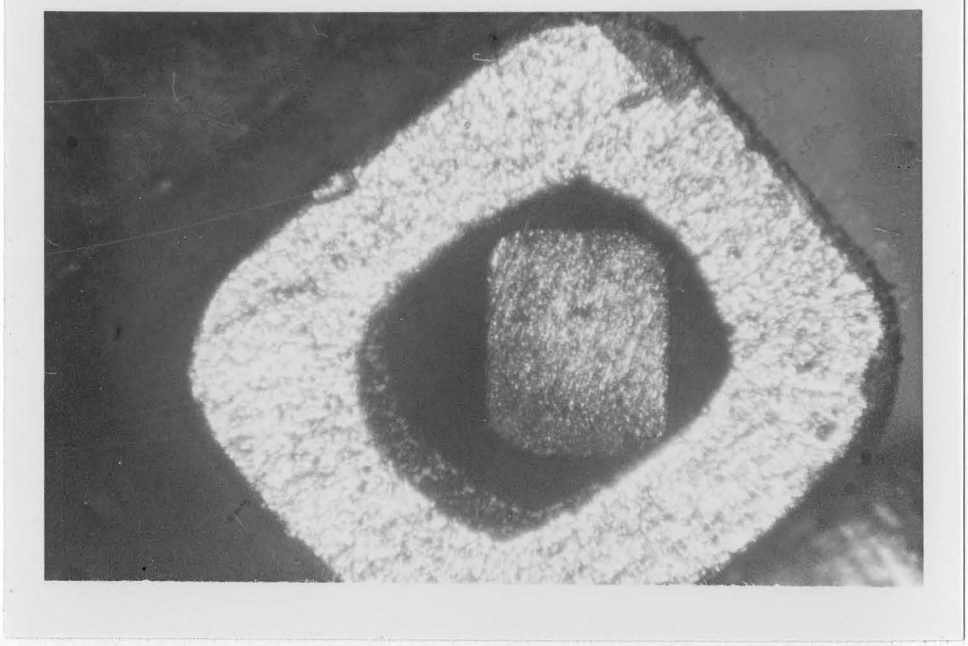


Figure 23. Rocky Mountain Drilled 0.022 x 0.028" tube
0.018 x 0.022" wire

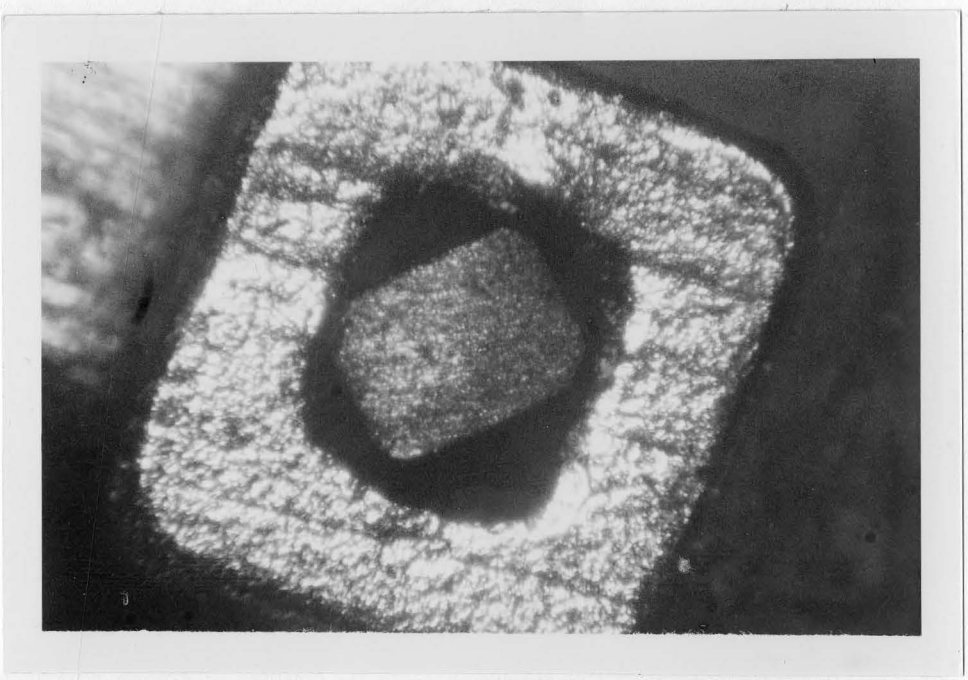


Figure 24. Ormco Drilled 0.022 x 0.028" tube
0.018 x 0.022" wire

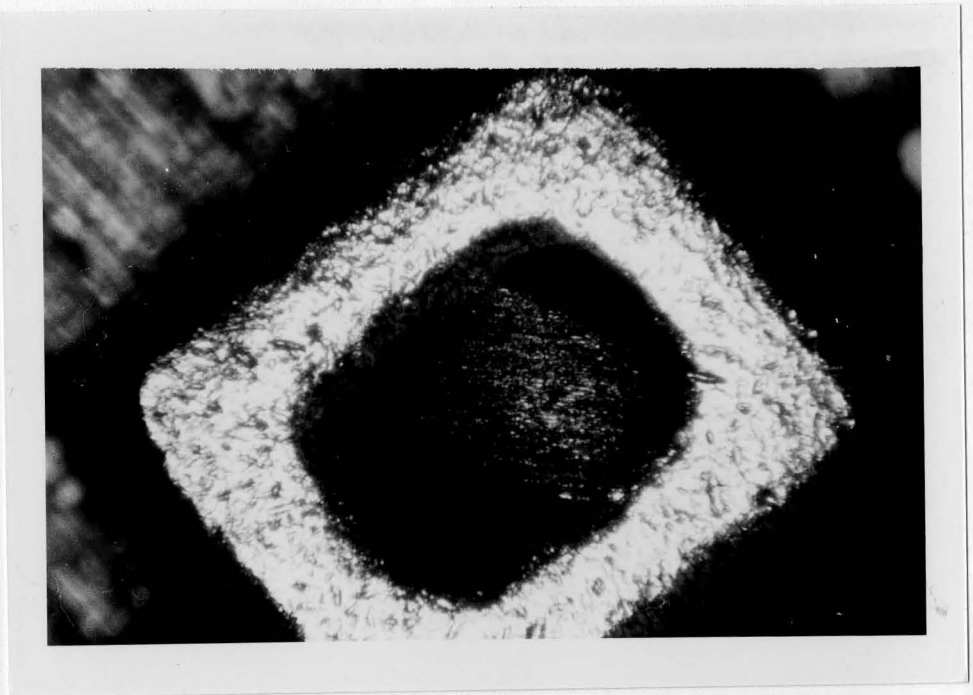


Figure 25. Unitek Drilled 0.022 x 0.028" tube
0.018 x 0.022" wire

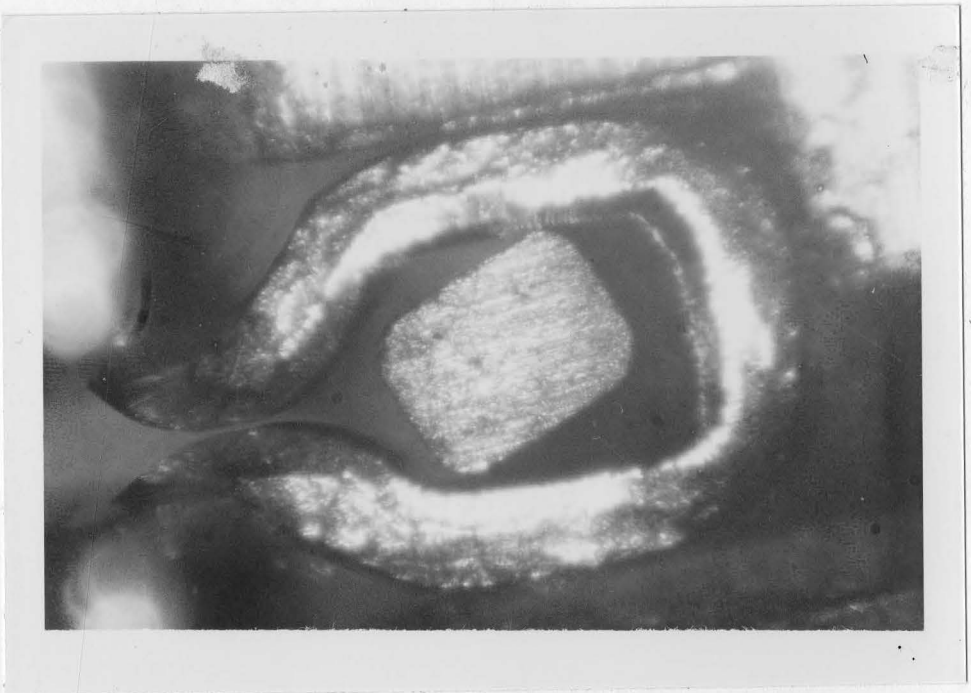


Figure 26. Rocky Mountain Mandrel 0.022 x 0.028" tube
0.018 x 0.022" wire

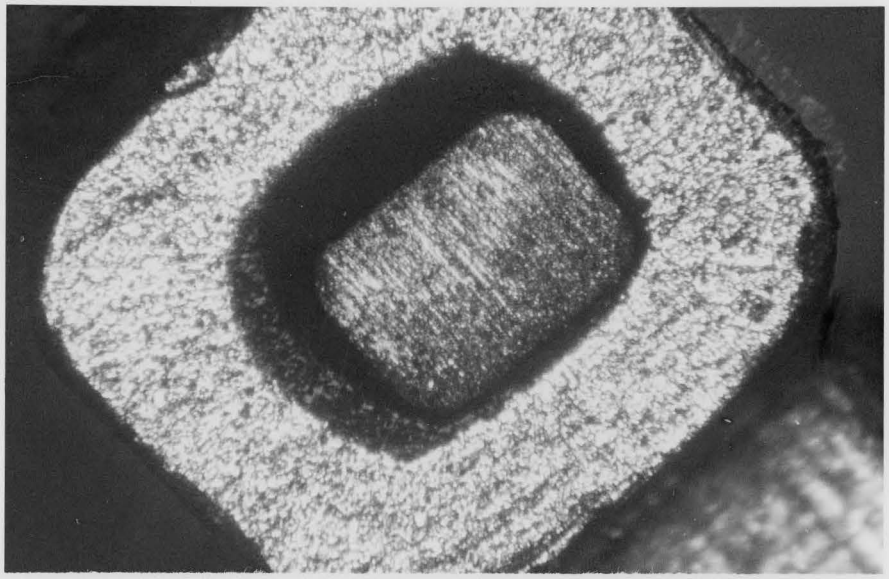


Figure 27. Rocky Mountain Drilled 0.022 x 0.028" tube
0.019 x 0.026" wire

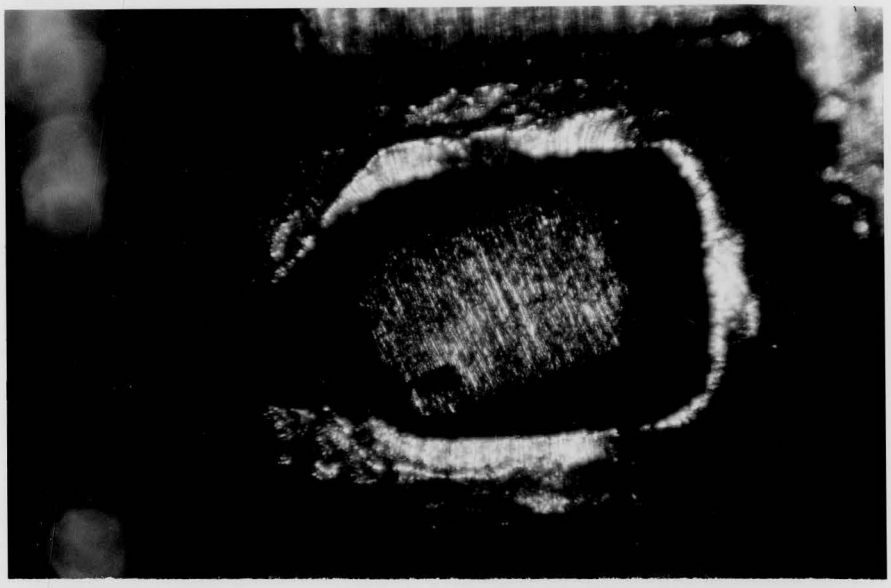


Figure 28. Rocky Mountain Mandrel 0.022 x 0.028" tube
0.019 x 0.026" wire

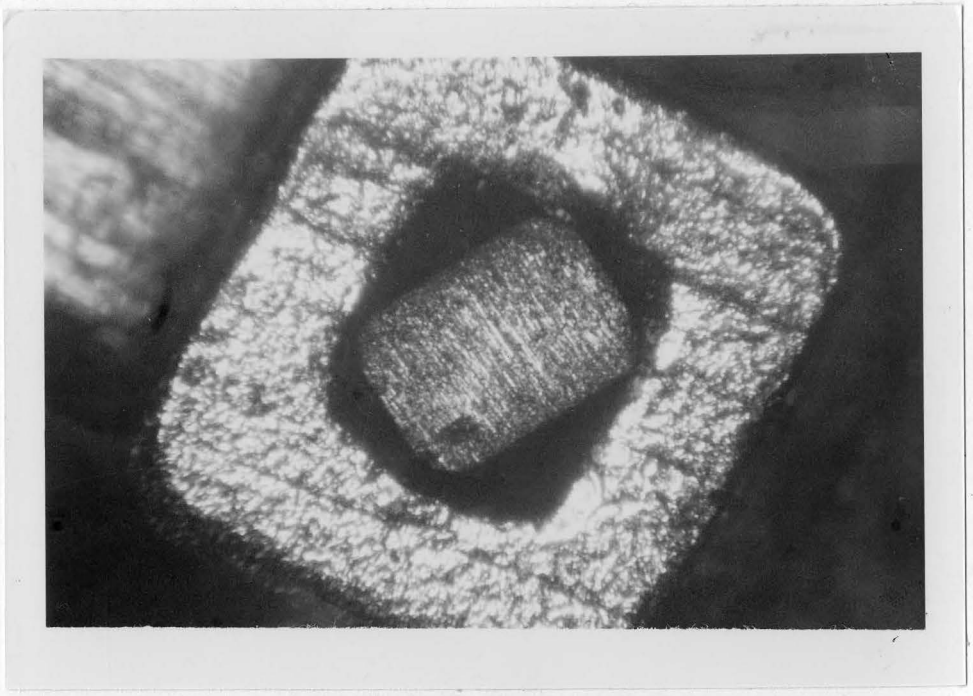


Figure 29. Ormco Drilled 0.022 x 0.028" tube
0.019 x 0.026" wire

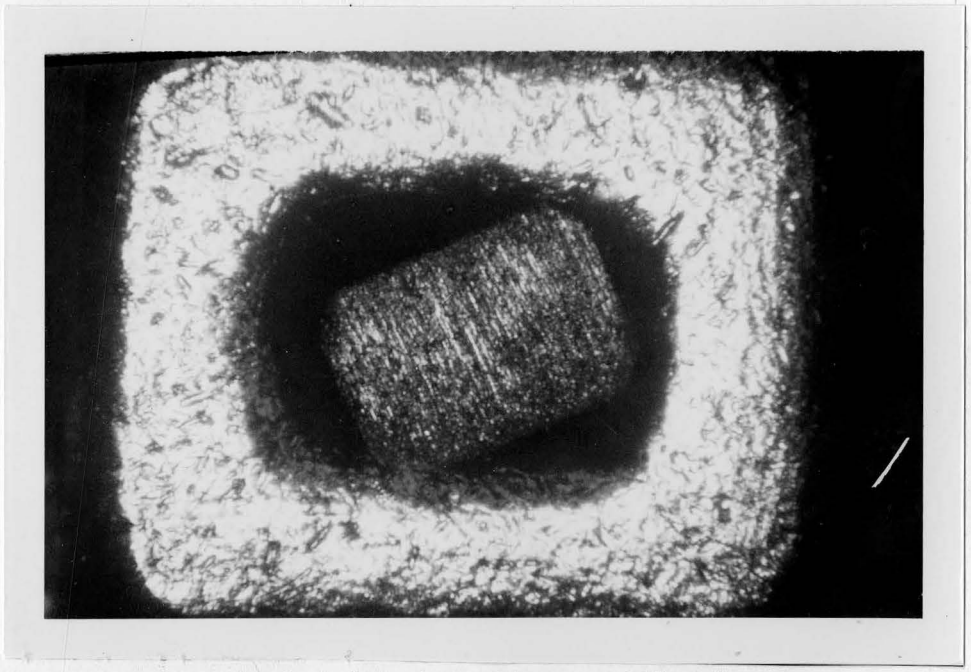


Figure 30. Unitek Drilled 0.022 x 0.028" tube
0.019 x 0.026" wire

Figure 31. Unitek Mandrel 0.022 x 0.028" tube
0.018 x 0.022" wire

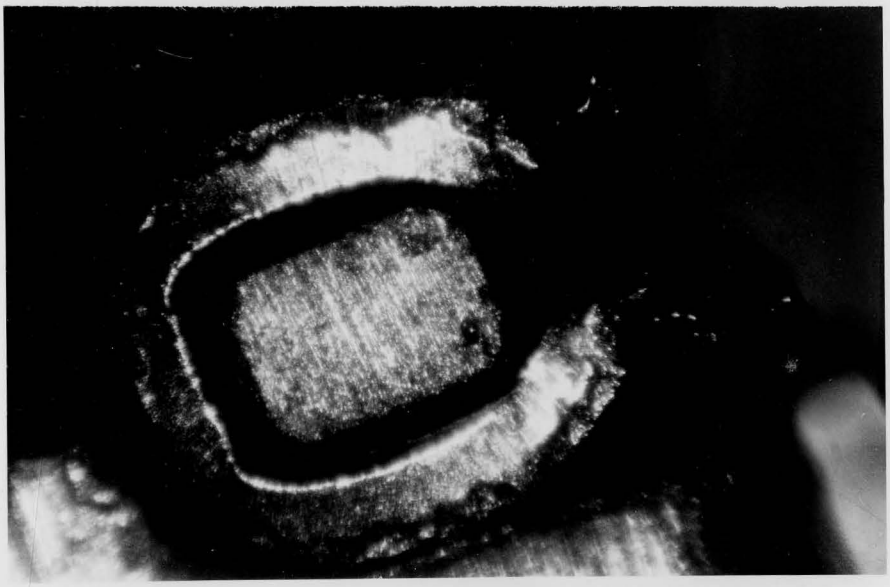


Figure 32. Unitek Mandrel 0.022 x 0.028" tube
0.019 x 0.026" wire

SUMMARY

The purpose of this study was the measurement and determination of the amount of rotation of rectangular wires within rectangular buccal tubes and the appreciation of this data as a means for making clinical judgments.

The experiment used two basic subjects:

1. Four wires, those used when .018 x .025" lumen size were:
   a. .016 x .016" square wire
   b. .016 x .022" rectangular wire

   When the tube's lumen size was .022 x .028":
   a. .018 x .022" rectangular wire
   b. .019 x .026" rectangular wire

2. Three types of molar tubes:
   a. drilled formed
   b. mandrel formed
   c. cast formed

A Unitron (model N) metallographic microscope was used and a Nikon adjustable rotatable stage was adapted so it could be mounted in the microscope. Two vises were designed: One, a holding vise that held the tubes and that was screwed on top of the rotatable stage, and the other one, being a spring loaded one that fastened the wires.

Problems were encountered when trying, first to position the tube at the center of the stage, and second, to position both, the wire and tube at the center of the stage.

The stage was moved, viewing on the microscope's screen the point where the wire engaged inside the tube's lumen. The stage indicated the amount of degrees it took the wire to bind, making six readings, clockwise and counterclockwise.

The results were recorded in five tables provided in this study. The lack of quality that exists in this field was observed and the appreciation of the data obtained was used as a means for mkaing clinical judgments.

Measurements wre also made on the lumen size of every tube, comparing the results obtained with the manufacturer's specifications. The wires used in the project were also measured and the comparison was also made between manufacturer's size and that of the experiment.

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APPROVAL SHEET

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The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the thesis is now given final approval by the Committee with reference to content and form.

The thesis is therefore accepted in partial fulfillment of the requirements for the degree of Master of Science.

April 10, 1978
DATE

James L. Sandrik
SIGNATURE OF DIRECTOR