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Scanning Electron Microscope Assessment of Several Resharpening Techniques on the Cutting Edges of Gracey Curettes

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Abstract

Aim: Treatment of periodontal diseases is based on efficient scaling and root planing (SRP) and adequate maintenance of the patient. The effectiveness of SRP is influenced by operator skill, access to the subgingival area, root anatomy, and the quality and type of instrument used for SRP. The aim of this study was to evaluate the cutting edges of Gracey curettes after manufacturing and after resharpening using several techniques.

Methods and Material: The cutting edges of a total of 41 new #5-6 stainless steel Gracey curettes were evaluated blindly using scanning electron microscopy (SEM). The quality of the cutting edges was evaluated blindly by a calibrated examiner using micrographs. Data were analyzed using a Kruskal Wallis test and non-parametric two-way multiple comparisons.

Results and Conclusions: Different sharpening techniques had significantly different effects on the sharpeness of cutting edges ($p<0.05$). Sharpening by passing the lateral face of curettes over a sharpening stone and then a #299 Arkansas stone produced a high frequency of smooth, sharp edges or slightly irregular edges between the lateral and coronal faces of the curettes. Sharpening by passing a blunt stone over the curette's lateral face produced the poorest quality cutting edge (a bevel). Sharpening of the coronal curette face produced extremely irregular cutting edges and non-functional wire edges. Sharpening with rotary devices produced extremely irregular cutting edges.

Keywords: Curettes, dental scaling, root planing, periodontal diseases, scaling and root planning, scanning electron microscopy

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Introduction

The primary etiologic factor in chronic periodontitis is bacterial biofilm which by direct and indirect mechanisms results in the destruction of the periodontium.[1] The root surface is exposed to endotoxins from the biofilm and becomes highly toxified.[2] This produces irreversible changes on the cementum, cell death, and a decrease in the number of fibroblasts[3] resulting in the reduction of biocompatibility between periodontal tissues and the root surface.

The treatment of periodontal diseases should be based on mechanical debridement (manual or ultrasonic) of supra- and subgingival biofilm,[4] atraumatic removal of calculus using scaling and root planning (SRP), daily oral hygiene procedures by the patient, along with regular professional maintenance visits. Although SRP is considered the gold standard for periodontal treatment,[5] its success is influenced by several factors such as the access to the subgingival area (mainly in furcation and interproximal sites), the cemento-enamel junction, root anatomy, the type of instrument, and operator skill.[6] All manual periodontal instruments have three functional angles: rake, clearance, and the lip (Figure 1). These angles together with the fineness and durability of the cutting edge are indispensable for appropriate instrumentation with minimal damage to the root surface. The aim of sharpening is to remove the blunt defects from the cutting edge to make it sharper without changing the structural and functional features of the instrument itself. Using scanning electron microscopy (SEM), this study aimed to assess the effect of ten standardized sharpening techniques on the cutting edge of #5/6 Gracey curettes.

Methods and Material

Forty-one new #5/6 stainless steel Gracey curettes (Neumar®, Sao Paulo, SP, Brazil) were used. The original factory sharpening was maintained for four of the curettes (Group 0). Thirty-seven curettes were blunted by scaling the enamel of extracted human teeth. One of these curettes was randomly selected as an example of a blunt curette. The remaining 36 curettes were randomly distributed and resharpened using nine different techniques as described in Table 1.

Blunt and resharpened curettes were evaluated using the bar test (Plastic test stick, LPTS Hu-Friedy, Chicago, IL, USA) and the index

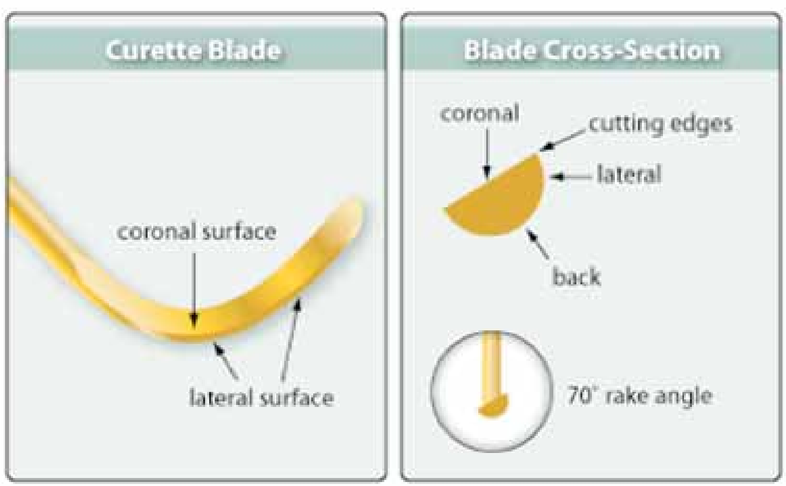

Figure 1. Parts of the working end of a #5/6 Gracey curette.

Table 1. Descriptions of sharpening techniques used for each group of Gracey curettes.

Group	Description of Sharpening Technique
1	Sliding the curette lateral face against a flat Arkansas SS6A stone (SS6A Hu-Friedy Mfg. Co., Inc., Chicago, IL, USA) towards the operator with a 100-110° angle between the stone and the coronal face.
2	Sliding the Arkansas SS6A stone around the edge from the stem to the cutting edge tip of the coronal face, followed by the lateral face (as in Group 1).
3	Sliding the Arkansas SS6A stone against the lateral face in upward and downward movements with a 100-110° angle between the stone and coronal face and always finishing with a downward movement.
4	Using an aluminum oxide cone (Shofu Dental Corp., Menlo Park, CA, USA) in a conventional speed handpiece at low speed placed against the coronal face and thereafter against the lateral face from the stem to the cutting edge tip.
5	Using a pen-shaped Arkansas 299 stone (299 Needle Stone Hu-Friedy) to slide against the lateral face with upward and downward movements at an 85° angle between the stone and the coronal face) finishing with a downward movement.
6	Sliding the lateral face of the curette against a standardized Premier sharpening device (Premier Dental Products, Plymouth Meeting, PA, USA).
7	Resharpening the coronal face with a Neivert Wittler Blade device (Wittler Instrument Sharpener, Darby Dental Co., Rockville Center, NY, USA) from the stem to the tip of the cutting edges.
8	Resharpening the coronal face with a Neivert Wittler Blade device followed by movement of the lateral face against an Arkansas SS6A stone.
9	Resharpening the coronal face with a Neivert Wittler Blade device from the stem to the tip of the cutting edges followed by abrasive powder and spinning a felt wheel on the curette's lateral face.

proposed by Hoffman et al.[7] This index considers a score of 4 as a blunt cutting edge (without resistance of the cutting edge on an acrylic bar surface) and a score of 1 as a sharpened edge (defined as stopping the cutting edge on the test surface). All of the evaluated cutting edges (new, blunt, and resharpened) were located between 1 and 5 mm from the tip which was defined as the experimental area.

The curettes were separated from their stems and photomicrographs of experimental areas were obtained (350x) with a SEM (Jeol JSM-T-330A, JEOL Ltd, Tokyo, Japan). The coronal face was always placed on the left side and the lateral face on the right side of the observation table. All examinations were made by a trained blinded examiner. The intra-observer agreement was calculated with two different evaluations using the Kappa-Light test ($p < 0.05$), which takes into account the contribution of agreement by chance. Next, the photomicrographs were evaluated by a single examiner (Kappa 98%) and classified according to the Cutting Edge Index developed for this study as follows:

- **Score 1:** A precise angle of the coronal and lateral faces without wire edges.

- **Score 2:** A slightly irregular cutting angle with or without wire edges.
- **Score 3:** A markedly irregular cutting angle with or without wire edges.
- **Score 4:** An undefined cutting angle with a presence of a bevel or a third surface.

The non-parametric analysis of variance (Kruskal-Wallis Test) was used in order to evaluate the effect of the techniques on the sharpening index, followed by a procedure of multiple comparisons 2x2.

Results

The different sharpening techniques had significantly different effects on the quality of the sharpness of the cutting edges ($p<0.05$). Average ranks were arranged in increasing order. The technique used in Groups 1 and 2 demonstrated the best results. The next best techiniques were those used in Groups 6 and 5 followed by Group 8. The worst results were found for the techniques in Groups 7, 9, 4, 0 (factory sharpening), and 3. However, the technique used for Group 7 demonstrated a slight advantage (Table 2).

No exact junction between the coronal and lateral faces (bevel) was found, and there were no defects in the cutting angle of the manufacturer sharpened curettes resulting in a score of 4 (Figure 2).

The technique used in Group 1 produced a precise and clear angle between the faces, creating a defined cutting angle without wire edges for a score of 1 (Figure 3).

The technique used in Group 2 showed slight irregularities for the cutting angle (score of 2) and a precise angle between the faces (Figure 4).

The technique used in Group 3 presented an ill-defined cutting angle and bevel formation between the faces resulting in a score of 4 (Figure 5).

Table 2. Probability values (p -value) after non-parametric comparisons of specific group average ranks for sharpening techniques (two procedures with *p* <0.05 are statistically different, according to the sharpening technique).

Technique	Rank (Median)	Technique								
		1	2	6	5	8	7	9	4	0
1	14.8									
2	17.5	0.81								
6	28.5	0.24	0.34							
5	29.5	0.20	0.30	0.93						
8	31.3	0.16	0.24	0.81	0.88					
7	44.8	0.01	0.02	0.16	0.19	0.25				
9	52.5	<0.01	<0.01	0.04	0.05	0.07	0.50			
4	53.5	<0.01	<0.01	0.03	0.04	0.06	0.45	0.93		
0	62.5	<0.01	<0.01	<0.01	<0.01	0.01	0.13	0.39	0.44	
3	70.3	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	0.13	0.15	0.50

Green: $p \leq 0.05$ Red: $p \leq 0.01$

The technique used in Group 4 provided an extremely irregular cutting angle and functional wire edges on the coronal face resulting in a score of 3 (Figure 6).

The technique used in Group 5 produced a slightly irregular cutting angle with some functional wire edges resulting in a score of 2 (Figure 7).

The technique used in Group 6 produced a moderate irregular cutting angle (score 2) with functional wire edges on the coronal face (Figure 8).

The technique used in Group 7 produced an extremely irregular cutting angle and non-functional wire edges on the lateral face of the cutting edge resulting in a score of 3 (Figure 9).

The technique used in Group 8 created a slightly irregular and a defined cutting angle, with an absence of wire edges resulting in a score of 2 (Figure 10).

The technique used in Group 9 produced an extremely irregular cutting angle with non-functional wire edges on the lateral face resulting in a score of 3 (Figure 11).

Discussion

Studies consistently demonstrate clinical improvement in chronic periodontitis in response to SRP make it the gold standard compared to other therapeutic modalities.[5] During SRP the features of the cutting angle are transferred to the root.[8,9] Therefore, it is important to understand how the cutting edge functions and how to create and maintain a delicate and fine-cutting angle between the coronal and lateral face (lip angle).

During manual SRP using curettes, only the cutting angle makes contact with the root surface and calculus forms an angular space existing between the lateral face and the root (clearance angle). This angle and the angle between the coronal face and the stem of the instrument (Rake angle) determines the capability of the instrument to remove deposits. A blunt instrument produces a large contact area between the lateral face and the root via the decrease in the clearance angle requiring an increase in the operator's hand strength and pressure. This makes it necessary to reestablish the cutting angle by resharpening the instrument. In increasing order the techniques used in Groups 1, 2, 6, 5, and 8 presented evaluation index scores equivalent to 1 or 2 which represents an improved quality of the cutting angle. The sharpening technique in Group 1 frequently created a precise angle between the cutting edge faces, without wire edges (Figure 3), which is in agreement with the reports of other authors[9,10,11,12] and confirms the theory that wear of the curettes occurs only on the lateral face. Therefore, only sharpening the face of the instrument is necessary which decreases the risk of metal loss as well as operator error during sharpening.

The wire edge is a non-supported metal projection and may be either functional or non-functional. The former are parallel to the scaling contact area and are created from sharpening the lateral face. Although wire edges may favor cutting efficiency because their irregularities tend to fracture the deposits, they do not contribute to the creation of a smooth root finish.[8,10,13,14] The non-functional projections are perpendicular to the scaling contact area and originate from sharpening the coronal face. This stretches the metal of the curette beyond the cutting trajectory which results in the irregularities of the non-functional wire edge to be transferred directly to the root surface. For these reasons, all the techniques (with the exception of the procedure used in (Group 7) used either lateral face sharpening or a combination of coronal face sharpening followed by lateral sharpening to avoid the formation of non-functional wire edges. Techniques used in Groups 2 and 8 created appropriate cutting angles, confirmed by DeNucci and Mader,[14] that were equivalent to those of Group 1. However, the coronal face sharpening introduced non-functional wire edges, obliging the sharpened lateral face to eliminate instrument generated defects, in contrast to the technique used in Group 1.

The standardized device used in Group 6 was expected to overcome the disadvantages of either the loss of control caused by the movement of the stone onto the instrument or even the lack of visualization of the cutting angle during the movement of the curette through the stone. The SEM assessment showed the formation of functional wire edges (Figure 8) suggesting minimal shifts while sliding the instrument on the sharpening guide. These errors can be inherent to the equipment or even to the abrasiveness of the stone. On the other hand, the techniques that used rotary resources (Groups 4 and 9) and the movement of the Arkansas flat stone (Group 3) against the lateral face produced a high incidence of markedly irregular cutting angles or even a bevel between the faces.

The main disadvantage of the technique used in Group 4 was maintaining the appropriate angle between the stone and the lateral surface. The stone tends to "stumble" while sliding through the cutting edge. This fact was associated with high rotation speeds, and the result is often a very irregular cutting angle and functional wire edges[4] (Figure 6). Coronal face sharpening (Group 9) was not able to eliminate non-functional wire edges or bevels between the faces (Figure 11), probably because the polishing powder employed was not an efficient abrasive in contrast to the results of other authors.[4,7,14] The sharpening sequence of sharpening the lateral face followed by the coronal face or only sharpening the coronal face (Figure 9) showed the formation of non-functional wire edges and marked irregular cutting angles, as observed by other authors.[8,10,14,15]

Since wear of the curettes occurs on the lateral face, sharpening must be performed upon this face rather than on the coronal face. Sharpening the coronal face may result in unnecessary wear of the metal, loss of cutting edge outlines, difficulty in maintaining the appropriate angle between the instrument and the stone, and the possibility of altering the efficiency of the clearance, rake, and lip angles. The instruments sharpened by the manufacturer showed bevels and wire edges (Figure 2), as confirmed previously,[7,9,10,14,16,17] indicating the need for every new instrument to be sharpened. In Group 3 great irregularities and functional wire edges were created which suggests the loss of control during sharpening (Figure 5) and indicates the need for either the stone or the curette to be fixed or anchored during the process.[18] In Group 5, although the technique requires a more skilled professional to establish an initial angle of 75º and then 85º during the movement of the stone onto the lateral face,[4] scores of 1 or 2 in the evaluation index were achieved. However, two evaluation index scores of 3 were also observed demonstrating loss of control (Figure 7). This technique is appropriate for maintaining the cut while avoiding total or partial blunting of the instrument.

The difference between techniques used in Groups 3 and 5 was mainly the contact area between the stones and the cutting angle. The Arkansas flat stone has a very large contact surface making movement and visibility difficult to control during sharpening, in contrast to the #299 Arkansas stone whose shape and contact area allows better control.

In addition to wear of the instrument and cutting edge maintenance other factors that may also influence the final outcome of the sharpening process include repetitive sterilization procedures using varying method[4] as well as the material from which the instruments are made.[16] Despite the clinical limitation in evaluating the state of the cutting angle,[8,7,16] obtaining a sharp angle is important because it directly influences operative time, operator stress and fatigue, instrument control and tactile sensitivity, as well as the efficacy of deposit removal.[4,7,9,16]

The results of this paper demonstrate the possibility of creating a cutting angle free from defects which may, in turn, provide benefits such as improved clinical performance, improved lifespan of instruments, and more predictable outcomes of root scaling and planing procedures.

Conclusion

Within the limitations of this study, the following conclusions can be made:

1. The sharpening techniques that employed the movement of the lateral face against the stone (Groups 1, 2, 6, and 8) together with the

technique used in Group 5 provided a better cutting angle with either a precise or a slightly irregular angle.

2. The sharpening technique that employed the movement of the stone on the lateral face (Group 3) produced a high incidence of undefined cutting angles with the formation of bevels or third surfaces.
3. The sharpening of the coronal face produced irregular cutting angles and non-functional wire edges. Therefore, when instrument coronal sharpening is carried out, it should be performed together with lateral face sharpening.
4. Rotary instruments, either employing an aluminum oxide cone or a felt wheel impregnated with an abrasive powder, demonstrated a high incidence of extremely irregular cutting angles or the formation of bevels.

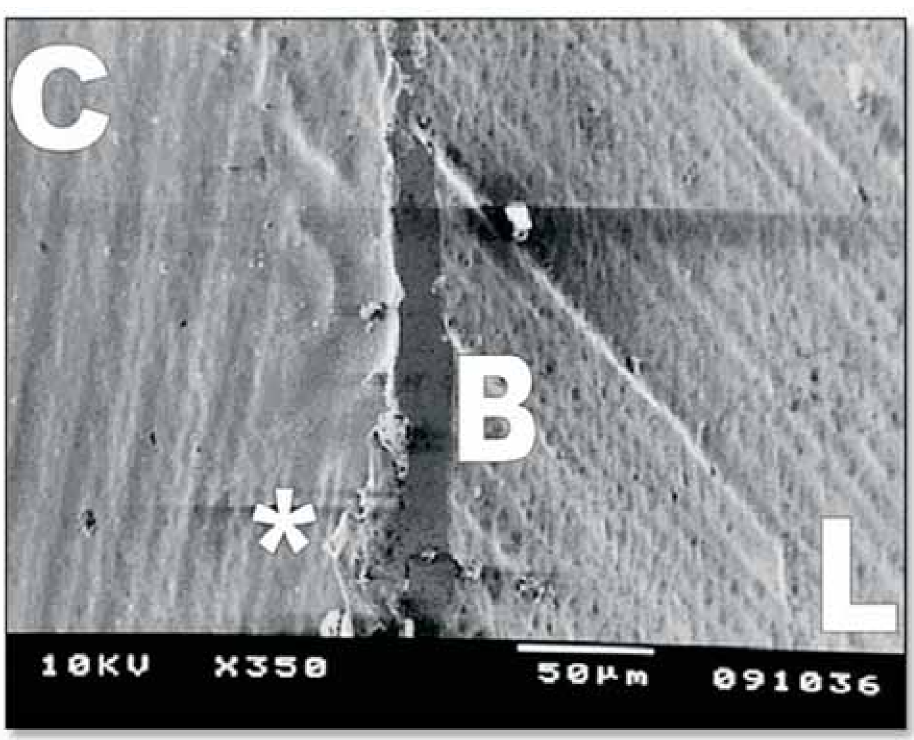

Figure 2. Factory sharpening with defects at cutting angle (*) and bevel (B) between the lateral and coronal face.

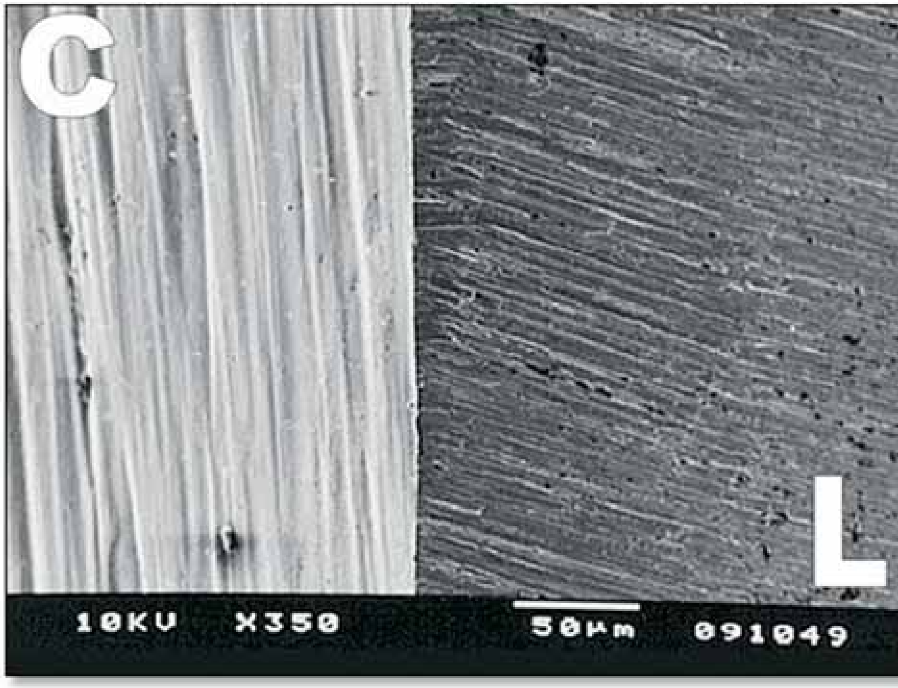

Figure 3. Group 1 sample showing a defined cutting angle with an exact junction between the coronal (C) and the lateral face (L).

Figure 4. Group 2 sample showing an exact junction between the coronal (C) and lateral face (L) and slight irregularities at the cutting angle (arrow).

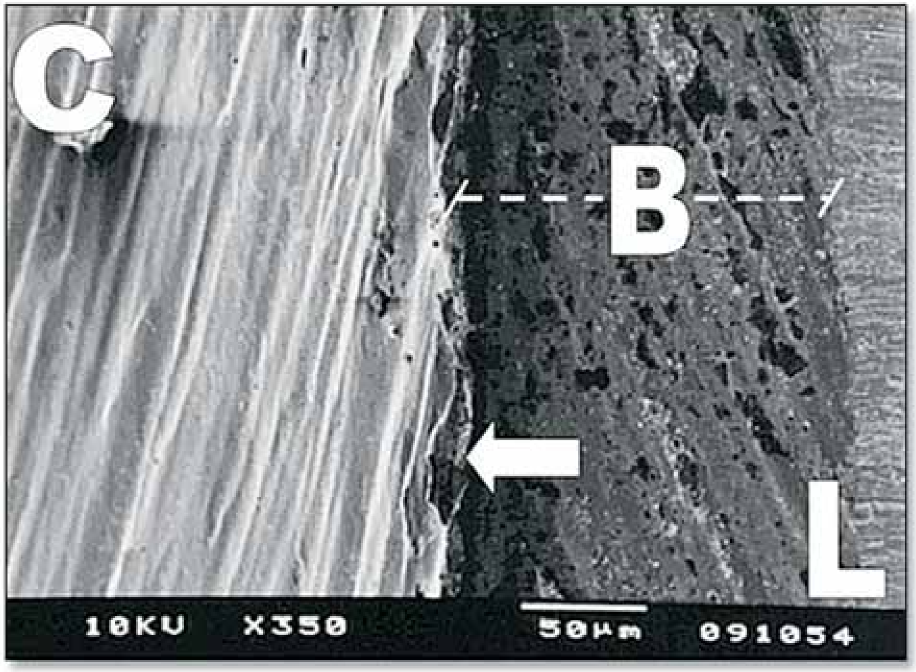

Figure 5. Group 3 sample showing functional wire edges (arrow) and a bevel (B) associated with the cutting angle between the coronal (C) and the lateral face (L).

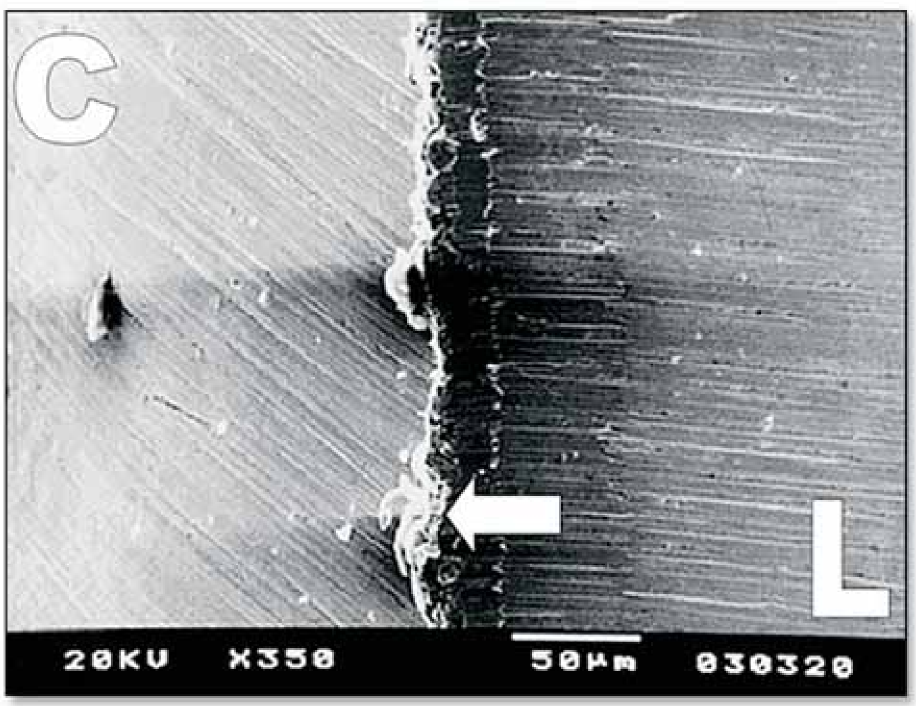

Figure 6. Group 4 sample showing functional wire edges (arrow) and extremely irregular cutting angle.

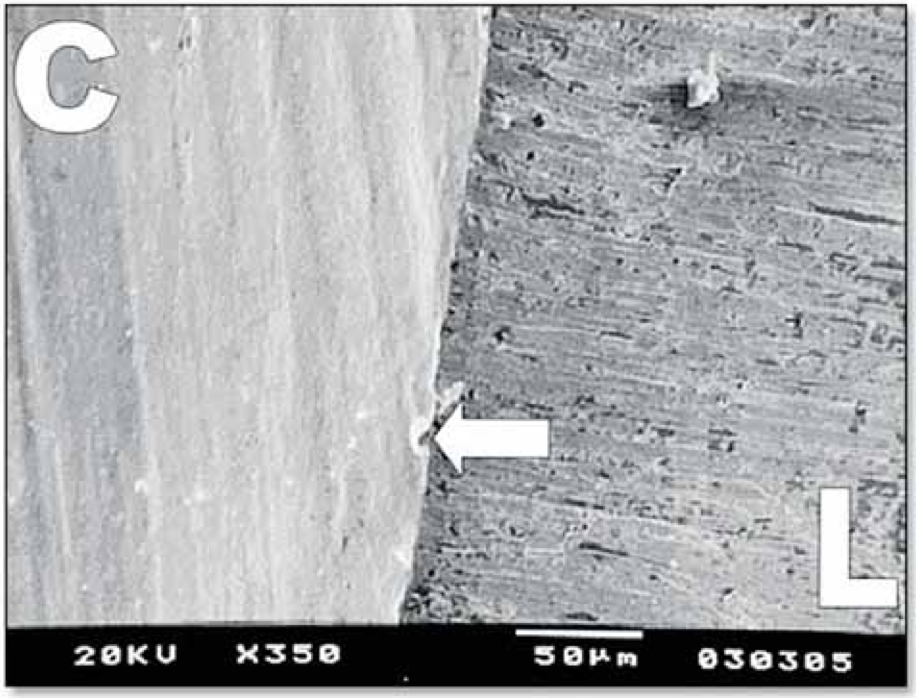

Figure 7. Group 5 sample showing a slightly irregular cutting angle with a few functional wire edges (arrow) between the coronal (C) and the lateral face (L).

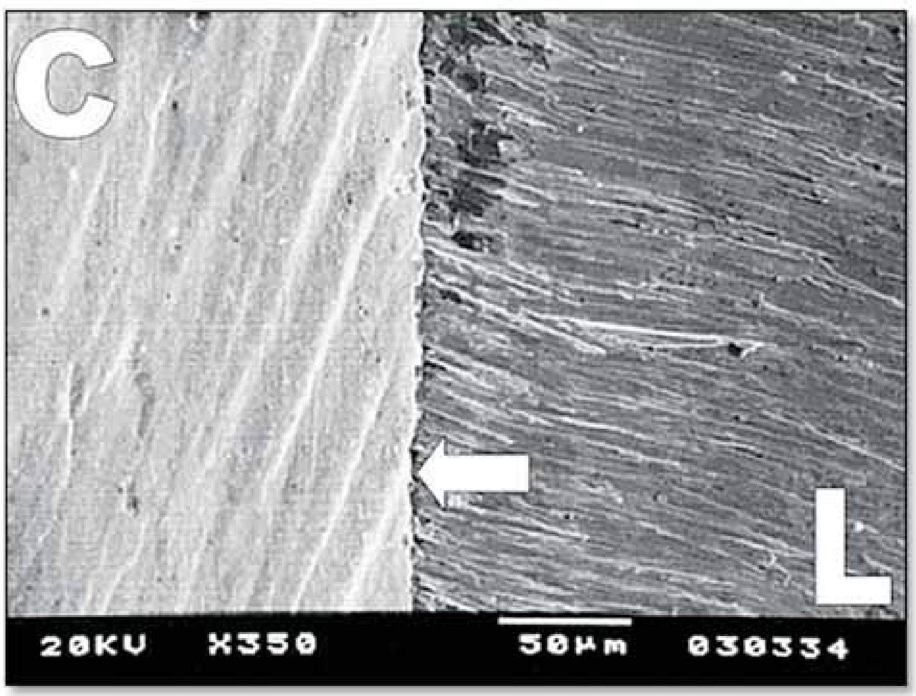

Figure 8. Group 6 sample showing a moderately irregular cutting edge (score 2) with functional wire edges (arrow) between the coronal (C) and the lateral face (L).

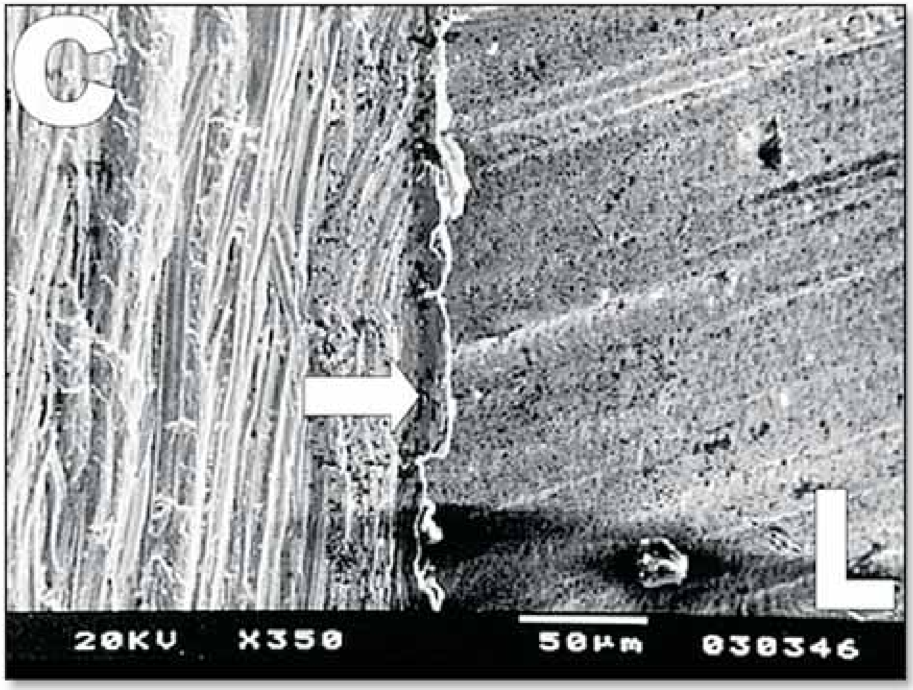

Figure 9. Group 7 sample showing an extremely irregular cutting edge with non-functional wire edges (arrow) between the coronal (C) and the lateral face (L).

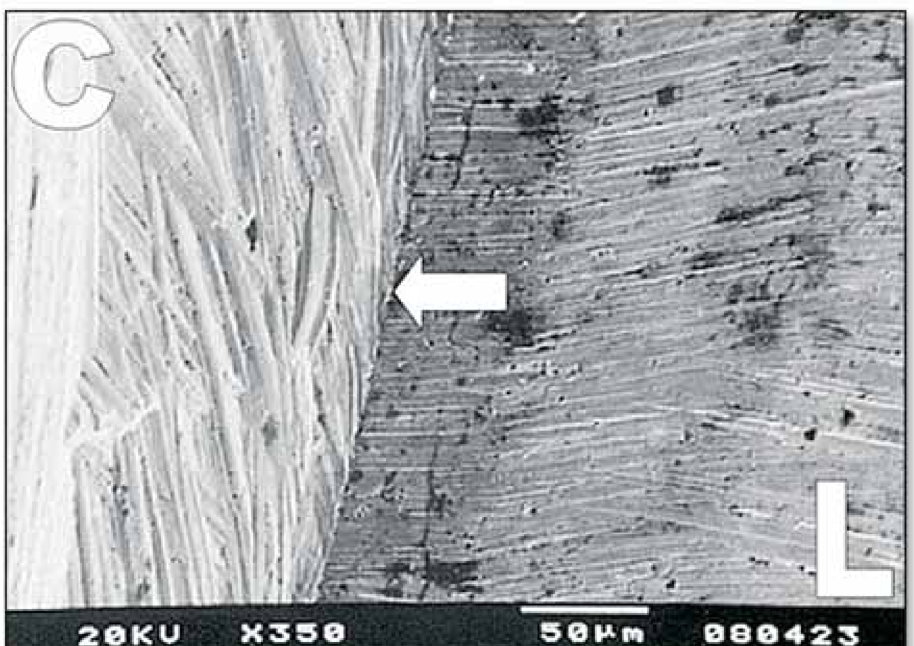

Figure 10. Group 8 sample showing a defined irregular slightly cutting angle, (arrow) without wire edges between the coronal (C) and the lateral face (L).

Figure 11. Technique 9 showing an irregular cutting angle and non functional wire edges (arrow) between the coronal (C) and the lateral face (L).

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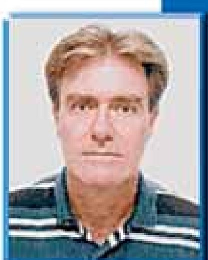

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