Alteration of Cutting Edge of Scalpel Blades After Incising Animal Gingiva

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Abstract

Scalpels in oral surgery usually causes deformation on its due to the exerted effort on tissues. As its use is repeated, it induces loss of cutting. Nevertheless, it has not been investigated enough and its possible effects on soft tissues. To describe cutting edge deformation of Bard-Parker #15 scalpel blades when cutting gingiva from ex vivo pigs.

Experimental study of 120 #15 scalpel blades divided into two groups according to manufactures. One to four cuts in gingival tissue of ex-vivo pigs were performed, effort experiments were carried out in an EZ-S SHIMADZU texturometer, applying a constant effort, with specific conditions. A photographic record was conducted on a stereoscopic microscope. Elite® blades presented effort values of 11.4329; 14,0798; 14,1642 and 14,8584 N, and for Paramount® blades values were 11.8975; 12.9730; 13.54 and 15.6428 N, when making 1, 2, 3 and 4 cuts respectively.

Significant differences were found ($p < 0.05$) for Elite® blades when making more than one cut. Blades deformation was present in both groups. Cutting effort directly influences on scalpel blades alteration, therefore, rheological effort increases with each incision, manifesting itself as a loss of cutting capacity.

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Introduction

It is known that surgical instruments experience a certain degree of deterioration or deformation when used, this is a usual characteristic of their employment and it has been previously mentioned by some authors.[1] Despite this, insufficient research has been done on how much effort should be made to achieve a proper cut without causing tissue damage when using a surgical instrument. Unfortunately, some professionals restrict themselves to expressions like: "is always like that", or “it is already known", falling into scientific obscurantism. In oral surgery, said situation allows to create a rational investigation, due to effect that deterioration of scalpel blades has on the pressure that must be applied to instruments to achieve an acceptable cut, when more than one, two or three incisions are made with a single standard blade.[2]

A scalpel is a stainless steel[3] cutting instrument, normally flat and straight, which allows to easily perform straight or linear cuts, some scalpels have a fixed blade, which permits to gradually curve it to obtain greater precision. Removable and interchangeable blades have a central slot to fit the handle, they are usually distinguished by a number that indicates their shape, depending on the type of incision they are designated to make. These types of blades allow clinicians to section tissue with minimal trauma; they are mostly used to incise skin, dissect connective tissue that covers an area that needs to be exposed, and to section structures.[4]

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An incision is a procedure by which tissues, skin or mucosa are opened, in order to reach deepest planes or to delimit tumor lesions and thus be able to carry out the main objective of surgical interventions. For this type of procedure, other elements such as electrosurgical units and scissors can be used.[5] Healing results from regeneration and repair processes, these correspond to a cascade of biological events that can be divided into 3 phases, an acute or inflammatory phase, followed by cell proliferation and finally culminating with tissue remodeling. After mentioned cascade will depend on cell dynamics, injured and its surrounding tissue, as well as cytokines and growth factors release.[6]

Bard-Parker scalpel, and especially blade #15 are widely reported in literature as very useful surgical tools. Despite being a permanent source of therapeutic and research experiences in both dentistry and medicine, they have not received necessary attention.[7] Therefore, is considered important within investigations groups to describe from the rheological point of view, physical deformations that can occur in blade's sharp edge as a consequence of its use when incising biological tissues, thus to define with greater precision how surgical procedures in oral cavities can be affected as a result of performing greater efforts on scalpels due to deformation of blades cutting edge.

This research approach becomes important since it can help to prevent possible alterations in oral tissues structure due to repetitive incisions during the same surgical act, which usually cause deformation on scalpel blades cutting edge, having as possible consequences production of irregular wounds, with poorly adaptable edges that can lead to long periods of heal and recovery. Research group that carries out present work has previously published research that presents deformation and resistance data of scalpel blades tested with a texturometer, but with a previous sample and a smaller size.[8] Said work provides in present time opportunities to obtain data that contributes to study deformation of scalpel blades cutting edges.

This study aimed to describe and compare deformation of #15 Bard-Parker scalpel blade cutting edges when they impact an ex vivo biological tissue such as pig gingiva.

Materials and methods

An experimental study was carried out in laboratories of the Faculty of Engineering of Cartagena University and in laboratories of GITOUC research group of the faculty of dentistry of Cartagena University (Colombia).

120 conventional #15 scalpel blades from two different manufacturers, Elite® and Paramount® were selected, considering as inclusion criteria those scalpel blades whose packages were in good condition and sealed and as exclusion criteria, any scalpel blades that presented fractures or showed an evident loss of continuity.

Two quantitative variables were studied, cutting effort and cutting-edge deformation in function of decreased cutting area, evaluated on an EZ-S Shimadzu texturometer (texture analyzer).

Experimental study

Initially, a photographic record of different groups of scalpel blades from both manufacturers was performed. Blades were placed using a millimetric background to position blades precisely and avoid movement. Photographs were taken using a Nikon D7000 camera and a digital stereoscopic microscope (DyD) at 4.5 magnification.

Evaluation of cutting capacity

Scalpel blades were sequentially placed on an EZ-S Shimadzu texturometer to make each cut. These blades were exposed to mechanical stress, which consisted of making a penetrating mucoperiosteal cut with an angle of 45° in pig's jaws used as an experimental model. Pig jaws were selected since they are an *ex-vivo* model that presents an adequate reproduction of human oral tissues, they are also easy to obtain, as they can be acquired commercially, so sacrifices were not necessary to develop this work.[7]

Incisions were made at a constant speed of 10 mm per minute. Once cuts were simulated, blades were placed in a standardized previously mentioned millimetric form and photographic record with a stereoscopic microscope was repeated to finally observe deformation degree or microscopic changes after performing incisions. This procedure was equally replicated when making two, three and four cuts.

Photographic description was carried out two times, firstly, photographs taken prior and after incisions were compared with each other to qualitatively determine if there was any deformation of scalpel blades cutting edge. Later, a digital comparison was made using Image J software, where scalpel blades cutting area was measured, information provided from before and after cuts was correlated using pixel-millimeters equivalency as previously mentioned.[9]

Statistical analysis

Descriptive statistic was employed to present information from collected data. For qualitative variable (deformation), results are expressed by frequencies and percentages, as for quantitative variables (cutting effort and scalpel blade cutting edge area) mean of values was used.

A one-way ANOVA was performed including data obtained for both evaluated scalpel brands, in the same way, results obtained for quantitative variables were also compared between both groups using the Newman-Keuls test. Measurements of cutting-edge area for each blade were carried out before and after cuts were performed, subsequently, Student's t-test (p <0.05) was conducted to determine variability of referred areas. Finally, photographic description and comparison between brands were also completed, according to Image J software analysis and results.

Results

Table 1 shows different values (Newton) of cutting efforts applied to Elite® scalpel blades, presenting mean values of 11.4329; 14,0798; 14,1642 and 14,8584 Newton for 1, 2, 3, and 4 cuts respectively. Although at first glance alterations of evaluated blades are evident, it is possible to see in Table 1 values of efforts practiced on scalpel blades from both commercial houses (Elite® and Paramount®), and results showed that values presented statistically significant differences (p<0.05), finding a maximum mean value when performing the fourth incision (14.85 N) and a minimum mean value (11.43 N) when making the first cut.

Cutting efforts (Newton)								
	First cut		Second cut		Third cut		Fourth cut	
Sample	*Elite®*	Paramount ®.	*Elite®*	Paramount ®.	*Elite®*	Paramount ®.	Elite®	Paramount ®.
1	10,53^{a}	12,11^{a}	14,87^{b}	14,90^{b}	15,90^{b}	16,00^{b}	16,20^{cb}	17,10^{c}
2	11,95^{a}	11,90^{a}	13,34^{b}	12,00^{a}	14.30^{bc}	12,20^{a}	15,27^{d}	16,20^{d}
3	7,910^{a}	9,900^{b}	11,80^{c}	11,20^{c}	12,10^{c}	11,00^{c}	13,12^{c}	14,20^{d}
4	8,247^{a}	10,00^{b}	12,60^{c}	12,10^{c}	12,15^{c}	11.40^{cb}	13,20^{d}	14,90^{e}
5	12,11^{a}	12,69^{a}	16,90^{b}	12,00^{a}	17,20^{b}	12.10^{a}	15,40^{c}	16,00^{b}
6	16,03^{a}	16,25^{a}	16,12^{a}	17.00^{a}	14,20^{b}	12,00^{c}	16,00^{a}	16,10^{a}
7	13,47^{a}	12.22^{b}	14,88^{c}	14,90^{c}	15,12^{c}	13.10^{a}	16,88^{d}	16,90^{d}
8	16,62^{a}	16,90^{a}	18,50^{b}	18,80^{b}	18,12^{b}	13,00^{c}	16.90^{a}	16,60^{a}
9	12,95^{a}	12,90^{a}	14,18^{b}	14,90^{b}	12,00^{a}	13,50^{ab}	14,00^{b}	14,20^{b}
10	10,98^{a}	11.00^{a}	13,10^{b}	14,00^{b}	13,40^{b}	13,60^{b}	14,60^{b}	14,90^{b}
11	11,31^{a}	12.77^{b}	14,40^{c}	12.50^{b}	14,88^{c}	14,60^{c}	15.96^{c}	16,30^{c}
12	9,254^{a}	10,00^{a}	13,00^{b}	10,20^{a}	14,14^{c}	14,90^{c}	15,22^{c}	16,20^{cd}
13	10,02^{a}	10,10^{a}	12,90^{b}	10,80^{a}	13,20^{b}	13,98^{bc}	14,10^{c}	14,40^{c}
14	8,990^{a}	9,120^{a}	11,80^{b}	9,900^{a}	13,20^{c}	13,30^{c}	14,27^{d}	14.44^{d}
15	11,09^{a}	10,90^{a}	12,80^{b}	12,95^{b}	12,69^{b}	14,40^{c}	14,90^{c}	15,00^{c}

Different letters in the same line have statistically significant differences (p<0.05)

Area variability of #15 Elite® and Paramount® scalpel blades			
manufacturer	Area variability of scalpel blades (mm). (N=120)		
	Before cut	*After cut*	*p* value*
Elite®	14,75	14,125	0,140
Paramount®	13,50	13,000	0,104

Table 1. Cutting efforts applied to #15 scalpel blades Paramount® and Elite®.

As can be observed in Table 1, reported area before performing cuts for Elite® scalpel blades were 14.75 mm, this area decreased significantly to 14.12 mm after making 4 cuts (p = 0.14). Similarly, for Paramount® blades, area before cuts was 13.5 mm and it was reduced to 13 mm after making referred incisions.

Table 2 shows descriptive statistics for effort values applied to #15 Elite® scalpel blades when performing 1, 2, 3 and 4 cuts, respectively. There are statistically significant differences (p <0.05) between mean values when performing 1 cut with respect to 2, 3 and 4 cuts. However, no statistically significant differences were found (P> 0.05) between mean values for 2, 3 and 4 cuts.

One-way analysis of variance	
P value	< 0,0001
P value summary	***
Are means signif different? (P < 0.05)	Yes
Number of groups	4
F	9,839
R square	0,345
Bartlett's test for equal variances	
Bartlett's statistic (corrected)	7,359
P value	0,061
P value summary	Ns
Do the variances differ signif. (P<0.05)	No

ANOVA Table.	SS	Df	MS
Treatment (between columns)	110,7	3	36,89
Residual (within columns)	210,0	56	3,750
Total	**320,7**	**59**	

Newman-Keuls Multiple Comparison Test	Mean Diff,	q	Significant? P <0,05?	Summary
1 cut vs. 4 cut	-3,635	7,270	Yes	***
1 cut vs. 3 cut	-2,740	5,481	Yes	***
1 cut vs. 2 cut	-2,647	5,294	Yes	***
2 cut vs. 4 cut	-0,988	1,976	No	Ns
2 cut vs. 3 cut	-0,093	---	NO	Ns
3 cut vs. 4 cut	-0,894	---	NO	Ns

Table 2. Descriptive statistics of cutting effort values applied to Elite® scalpel blade #15.

Table 1 shows different values of cutting efforts (N) for Paramount® scalpel blades, presenting mean values of 11.8975; 12.9730; 13.54 and 15.6428 Newton for 1, 2, 3 and 4 cuts respectively. Cutting effort for this scalpel blade brand have a maximum value of 14.64 N when making 4 continued incisions in pig gingiva, and a minimum value of 11.89 N when making only one cut.

Table 3 shows descriptive statistics of cutting efforts applied to #15 Paramount® scalpel blades when making 1, 2, 3 and 4 continued cuts on pigs gingiva, Anova results showed that when comparing cuts 1 vs. 4, 3 vs. 4, and 2 vs. 4, statistically significant differences were found (P <0.05). Nevertheless, such differences were not found when analyzing cuts 1 vs. 2, and 2 vs. 3 respectively.

Figure 1 shows results of Newman-Keuls Multiple Comparison Test for #15 scalpel blades Elite® and Paramount®. Mean cutting effort value for Elite® blades when making a single cut showed statistically significant differences (p <0.05) with Paramount® blades mean value when making 3 and 4 cuts. Statistically significant differences (p <0.05) were also found between values when performing 2 and 3 cuts using Elite® blades, compared to Paramount® blades when making one single cut. When making 4 cuts employing Elite® blades, differences were found (p <0.05) only when compared to values reported for Paramount® blades when making 1 and 2 cuts.

One-way analysis of variance	
P value	< 0,0001
P value summary	***
Are means signif different? (P < 0.05)	Yes
Number of groups	4
F	9,599
R square	0,3396
Bartlett's test for equal variances	
Bartlett's statistic (corrected)	13,320
P value	0,0046
P value summary	**
Do the variances differ signif. (P<0.05)	Yes

Anova Table.	SS	df	MS
Treatment (between columns)	103,4	3	34,48
Residual (within columns)	201,1	56	3,592
Total	**304,6**	**59**	

Newman-Keuls Multiple Comparison Test	Mean Diff,	q	Significant? P <0,05?	Summary
1 cut vs. 4 cut	-3,645	7,45	Yes	***
1 cut vs. 3 cut	-1,355	2,768	No	Ns
1 cut vs. 2 cut	-1,293	---	No	Ns
2 cut vs. 4 cut	-2,353	4,808	Yes	**
2 cut vs. 3 cut	-0,062	---	No	Ns
3 cut vs. 4 cut	-2,291	4,681	Yes	**

Table 3. Descriptive statistics of cutting effort values applied to Paramount® scalpel blade #15.

Figure 1. Results of the Newman-Keuls Multiple Comparison Test for scalpel blades #15 Elite® and Paramount®.

As we can see in Figure 2, there are alterations in the edge of scalpels blade after use in animal tissues.

Discussion

Scientific publications regarding deformation of scalpel blades because of their use are very limited or even null. There is a report where they evaluated the distortion of dental needles used for local anesthesia, their design, their impact on tissues and deformation due to their use. Results showed that damage in oral tissues is usually higher when needles don´t have a particular design that prevents deformation.[10] Those outcomes can be extrapolated with results found about scalpel blades deformation in this study, it even opens a new option such as developing new scalpel blade designs that might minimize trauma due to their edge deformations, in a similar way to new anesthetic needles design.

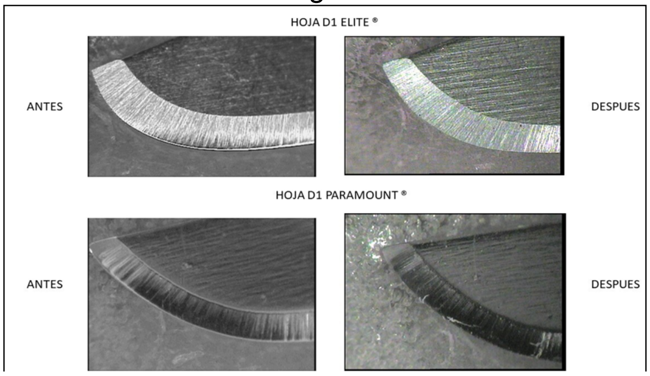

Figure 2. Front view of scalpel blades after making cuts. It can be seen alteration or deformation in cutting edges of scalpel blades.

According to results obtained in the present study, it can be emphasized that scalpel blades undergo an evident deformation process, which induces operators to use greater efforts to cut tissues when making more than one wound, these elevated efforts consecutively increase tissues resistance to deformation, an event that goes against a proper healing course, given the fact that when there are more modifications or alterations during surgical procedures, healing becomes a more complex and delayed process.[11]

It is important to mention that in a previous paper were showed histological results when analyzing effects of a super pulsed CO2 laser scalpel on *ex vivo* tissues. Researchers made cuts with different types of scalpels and then, histologically analyzed them.[12] This work development contrasts with the current study since histological analyzes were not performed, yet, it represents an excellent option to include as a future improvement. It is certainly interesting that different levels of tissue damage due to surgical instrument deformation are reported even when using high-technology scalpels. It is important to remark that after-mentioned publication does support using an ex vivo model to carry out analyses.

A relevant discussion must be generated between oral clinicians about implications of repeating incisions using one single scalpel blade as well as its possible consequences on soft tissue healing processes. Such as it was suggested that certain parameters should be monitored when incising soft oral tissues with scalpels or other surgical tools.[13]

Within this research group, it is desired to keep exploration about different tissue models in order to accurately and safely determine required efforts to make surgical incisions on gingiva and trough that, establish experimental mechanical properties that are required to provide a much safer and reliable predictive model in order to develop surgical competencies.[14]

Bard-Parker Scalpel Blades number 15 are widely used for oral surgery and they remain as gold standard for procedures that involve excision, incision, or dissection of soft tissues due to their ability to perform fine and clean cuts that will finally promote a correct healing process, these mentioned concepts are consentient with previous reports.[15] Different studies have compared some aspects of using laser in the oral cavity. As reported before[16], who studied especially those characteristics related to healing processes after performing gingivectomies, these authors found significant differences regarding wounds appearance and cicatrix formation; they found that wound thickness was much greater when scalpels were used, so it can be inferred that relevance of scalpel as a cutting instrument and its role on wounds and healing is evident when compared to other incision instruments, however, authors did not evaluate deformation presented by scalpel blades according to the applied effort.

Conclusions

Effort that must be made from the rheological point of view increases when a single blade is employed for more than one cut in the evaluated tissues. Cuts performed when using #15 Bard-Parker scalpel blades, produce significant physical deformations in all the evaluated scalpel blades cutting edges.

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Declaration of Interest

The authors report no conflict of interest.

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