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Can Osteotomes Be Sharpened in the Operating Room Inexpensively and Effectively? An Experimental Study on Sandpaper Versus Arkansas Stone

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ABSTRACT

Objective: The maintenance of surgical instruments is an ongoing problem for surgeons, especially in operations such as rhinoplasty where instrument sharpness is very important. This study aims to investigate the effectiveness of two inexpensive and easily accessible sharpeners that can be used in the operation room immediately before surgery.

Materials and Methods: Three new Cinelli osteotomes were subjected to base sharpness measurements and then used to cut same-sized artificial bone blocks by applying hammer blows with equal force. The three osteotomes were placed into different groups as follows: the no-sharpening (NS) group, the Arkansas stone (AS) group, and the sandpaper (SP) group. Sharpness measurements were repeated in all groups after the 1st, 4th, 7th, and 10th osteotomies.

Results: No significant difference was found between the initial measurements with the sharpness values measured after the 10th osteotomy in the NS and AS groups ($p>0.05$). The dullness in the SP group, however, increased significantly through the process.

Conclusion: Using new osteotomes without resharpening them after their first use until they have become blunt may be appropriate. If sharpening is to be done, an Arkansas stone will likely provide better results than sandpaper.

Keywords: Osteotome, sharpness, sandpaper, arkansas stone

INTRODUCTION

The sharpness of an osteotome is extremely important in external nasal surgery for obtaining acceptable results and avoiding complications in nasal hump reduction, with greater sharpness providing more controlled bone cuts. Blunted osteotomes can cause the separation of larger bone fragments instead of only those in the desired area, as well as soft tissue damage. In addition, bone fragment ruptures that occur near the base of the skull can cause serious complications (1-3).

Because medical centers generally have no devices for checking instrument sharpness, the falls on the surgeon to have sharp, well-functioning instruments (1). In addition, no consensus currently exists regarding what materials to use or how often surgeons should sharpen their osteotomes. While some surgeons prefer to sharpen them themselves before or after each case, others have professional manufacturing companies perform the sharpening at certain intervals (e.g., every four months). However, professional sharpening results in large amounts of erosion of the steel, and this has been reported to reduce the life of osteotomes (4, 5).

Ceramic stones, diamond stones, Arkansas stone, Indian stone, aluminum oxide stones, stone engines, and sandpaper are among the materials that can be used in the sharpening process (1, 5). Comparisons of the sharpening results of fine-particle stones (e.g., Arkansas, aluminum oxide) and larger-particle stones (e.g., India and diamond stones) have shown

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fine-particle stones to provide more successful results in terms of sharpness (6). An inexpensive alternative to sharpening stones is to use sandpaper made from silicon carbide, which can then be glued to a piece of wood and used as a sharpening stone (7). Although sandpaper is not a frequently used material in osteotome sharpening, the study has chosen it due to being an inexpensive and easy method that is frequently preferred in daily life for knife sharpening.

Surgeons generally decide when to sharpen instruments by feel (4, 5). Most facial plastic surgeons tend to sharpen their instruments themselves when needed. Therefore, this study aims to compare the effectiveness of Arkansas stone and sandpaper, two different and easily accessible materials that can be used for sharpening under operating room conditions.

MATERIAL AND METHODS

Study Design

This prospective study received exemption approval from the institutional review board of Samsun Training and Research Hospital, a tertiary hospital in Turkey, as the study does not use human tissue. Following the approval from the ethics committee, the study and all measurements were carried out at the Samsun Training and Research Hospital. This study has been funded by the Samsun Training and Research Hospital (Date: 26.09.2019, no: KAEK 219/2/24).

Method for Measuring Sharpness

This study has used three new identical 10 mm Cinelli Osteotomes (Karl Storz, Tuttlingen, Germany; Figure 1c). To realistically simulate nasal osteotomies, a 90-degree complete vertical cut was made to an artificial bone (4 mm wide, 4 cm thick) with a density of 40 PCF (pounds per cubic foot; Sawbone, Sawbones Europe AB, Malmö, Sweden) by applying hammer blows of equal force to all the osteotomes (Figure 1b). A crank-based hammering system was designed, with a latch under the hammer crank that always allowed the crank to drop and hit the osteotome from the same height. A load cell with a touchscreen (Centor Star Touch, Comten Inc., Florida, USA) was used to measure the force transmitted to the osteotome (Figure 2b). The first author (C.B.) hammered the osteotomy three times, and 80 pounds (lb) of effective force was seen to be transferred on average. The height from which to drop the free hammer to create the same force was determined, with the hammer being consistently released from this height. Meanwhile, the mallet strokes made on the artificial bones were performed at equal strength (Figure 2a; Supplemental Video 1).

Figure 1: a) Sandpaper with 500 and 1,000 grit, cut into 10 mm thin strips and waiting to be bonded to wooden blocks for sharpening; b) Fine and c Arkansas stones (shown as >>) with 500 and 1,000 grit and artificial bone blocks (*); and c) 10 mm Cinelli osteotome (Karl Storz, Tuttlingen, Germany).

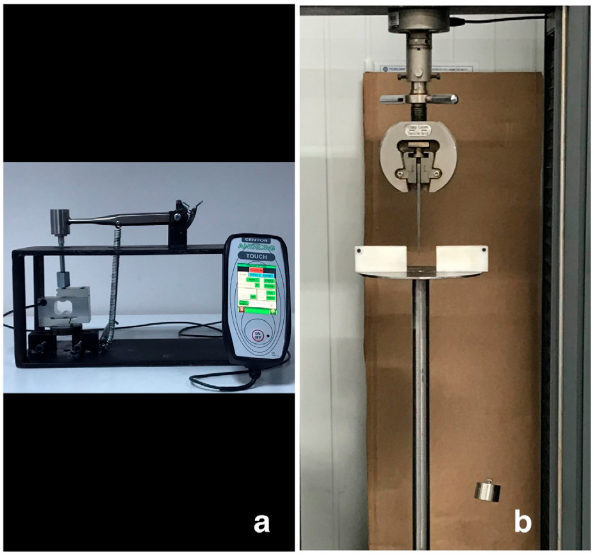

Figure 2: a) A hammer crank-based system and a load cell with a touchscreen (Centor Star Touch, Comten Inc., Florida, USA), b) Preparation of the test setup by adding 370 g weight of 5/0 polypropylene suture (Prolene, Ethicon Inc., Somerville, New Jersey) after placing a Cinelli osteotome into the WDW-350 Electronic Universal Testing Machine (TIME Group Inc., Beijing, China).

Supplemental Video 1: A hammer crank-based system always being dropped from the same height once the latch is released and hitting the osteotome forward.

All the osteotomes were made by the same manufacturer at the same size and weight and had original factory sharpness. Equal forces were applied to the osteotomes, and strokes were repeated until a full-thickness cut had been made in the artificial bone. The sharpness of all three osteotomes was measured at the baseline and after the 1st, 4th, 7th, and 10th complete osteotomies. These osteotomy sequences and measurements were designed based on those from Ransom et al. (5).

One of the three osteotomes was used in each of the following groups: the no-sharpening (NS) group, the Arkansas stone (AS) group, and the sandpaper (SP) group. In the AS and SP groups, the osteotomes were sharpened after the 1st, 4th, 7th, and 10th complete osteotomies, with three measurements then being repeated for each group (Figure 3).

Grit as a term refers to the number of particles per square inch (6). This study used coarser 500 grit followed by finer 1,000 grit for the both Arkansas stone and the sandpaper sharpening, applying the same technique to both (Figure 1a).

To measure the sharpness of the osteotomes, this study used the test setup Bloom et al. and Ransom et al. had created (4, 5). For this purpose, the double-guided Cinelli Osteotome was placed in a WDW-350 Electronic Universal Testing Machine (TIME Group Inc., Beijing, China), and then a monofilament 5/0 polypropylene suture (Prolene, Ethicon Inc., Somerville, New Jersey) was tied tightly (Figure 2b). This study fixed the suture material with a specially designed holder, and a 370-g weight was attached to the other side to create the necessary tension as described in Bloom et al.'s (and Ransom et al.'s measurement models (4, 5). Using the universal tester and holder, each osteotome was advanced downward into the suture at a constant speed (5 mm/min) until the suture was cut. The universal tester generates a force displacement curve. The force at the time of cutting is inversely proportional to the sharpness of the blade. In other words, the lower the force used to cut the suture, the sharper the blade. The force used to have the osteotome cut by applying pressure to the suture was measured and recorded in Newtons (N).

No sharpening (NS) group	Arkansas stone (AS) group		Sandpaper (SP) group	
Baseline measurements				
0,41	0,48		0,35	
0,50	0,65		0,38	
0,46	0,22		0,58	
1st osteotomy				
	Post-osteotomy	Post-sharpening	Post-osteotomy	Post-sharpening
0,51	0,59	3,39	1,19	1,97
0,39	0,17	2,80	1,45	1,66
0,50	0,10	1,37	0,38	1,77
4th osteotomy				
0,74	4,04	5,32	1,07	3,03
0,69	4,69	4,98	1,32	3,01
0,58	0,69	3,83	1,94	3,35
7th osteotomy				
1,32	3,64	1,68	3,24	5,07
0,79	3,50	4,08	2,63	5,60
0,76	1,46	2,24	3,13	6,80
10th osteotomy				
0,60	0,66	1,10	5,70	7,38
0,88	0,54	1,82	5,49	6,72
0,67	0,16	2,07	4,91	7,50

Figure 3: Graphic of the sharpness measurement of the groups at baseline and following the 1st, 4th, 7th, and 10th osteotomies and sharpening sessions.

Sharpening Technique

The study uses the hand-sharpening protocol described by Gryskiewicz et al. (3). In accordance with this protocol, forward-pressure pushes were performed 10 times on both sides of the osteotome at a 30-degree inclination. These were followed by 10 forward strokes at a 45-degree angle to both sides at less pressure, with one very gentle final forward stroke at a 60-degree angle. All sharpening was done by the same senior author (C.B.) using the same technique.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS, version 21.0; IBM Corp., Armonk, New York, USA) was used for the data analysis. Comparisons among the three groups were made using one-way analysis of variance (ANOVA), with the post-hoc Tukey honestly significant difference (HSD) test being performed for significant comparisons. The paired t-test was used to compare the measurements among the osteotomies. Lastly, the Pearson correlation test was used to show the relationship between the sharpness and the number of osteotomies in each group, with a $p<0.05$ being considered statistically significant.

RESULTS

No significant differences were found among the groups regarding the baseline measurements for all three Cinelli osteotomes ($p=0.986$). However, significant differences were observed in all of the comparisons among the groups after the 1st, 4th, 7th, and 10th osteotomies and the sharpening processes ($p<0.05$). After the 1st osteotomy and sharpening, the osteotomes in the AS group had become significantly blunted. After the 4th osteotomy sequence, the osteotomes in the AS (the dullest one) and SP groups were found to have become more significantly blunted (Table 1).

The AS group experienced a visible fracture after the 7th osteotomy, and the sharpness value decreased to the point that no difference appeared between the AS and NS groups in the last two measurements. Meanwhile, the SP group saw its sharpness continue to become increasingly blunted; this group received the worst score after the 10th osteotomy, significantly worse than the other osteotomes (Figure 3).

When evaluating the groups separately, the NS group could easily be seen to have been much more stable. When evaluating the paired comparisons within the groups, no significance was observed in the NS group ($p\geq0.05$). In the AS group, a strongly significant difference occurred in the comparisons between the base and 4th osteotomy and between the 1st and 4th osteotomies ($p=0.00$). In the SP group, on the other hand, the sharpness consistently became blunter, with strongly significant differences being observed in all paired comparisons except for between the 7th and 10th osteotomies. When comparing

Table 1: Comparison of sharpness scores (Newton) among groups inter-osteotomy and sharpening procedures

	No sharpening (NS) group	Arkansas stone (AS) group	Sandpaper (SP) group	P value^{Y}
	(Mean ± *SD*)	(Mean ± *SD*)	(Mean ± *SD*)	
Base measurement	0.45 ± 0.04**a**	0.45 ± 0.21**a**	0.43 ± 0.12**a**	0.986
1st osteotomy	0.46 ±0.06**a**	2.52 ± 1.03**b**	1.80 ± 0.15a**b**	**0.016**
4th osteotomy	0.67 ± 0.08**a**	4.71 ± 0.78**b**	3.13 ± 0.19**c**	**0.001**
7th osteotomy	0.95 ± 0.31**a**	2.66 ± 1.25**a**	5.82 ± 0.88**b**	**0.002**
10th osteotomy	0.71 ± 0.14**a**	1.66 ± 0.50**a**	7.20 ± 0.42**b**	**0.001**

Y : One-Way ANOVA test , **a/b/c** letters show intergroup difference in each row (Post Hoc test-Tukey HSD test**),** statistically significant *p* values are emphasized in bold. *SD* = Standard deviation.

Table 2: Paired comparisons of base measurements and measurements after the 1st, 4th, 7th, and 10th osteotomy and sharpening for each group

	No sharpening (NS) group	Arkansas stone (AS) group	Sandpaper (SP) group
Base – 1st osteotomy	.887	.056	**.009**
Base – 4th osteotomy	.075	**.007**	**.000**
Base - 7th osteotomy	.135	.077	**.007**
Base - 10th osteotomy	**.050**	.076	**.001**
1st osteotomy - 4th osteotomy	.089	**.005**	**.013**
1st osteotomy - 7th osteotomy	.097	.890	**.019**
1st osteotomy - 10th osteotomy	.177	.427	**.001**
4th osteotomy - 7th osteotomy	.193	.131	**.022**
4th osteotomy - 10th osteotomy	.680	.051	**.002**
7th osteotomy - 10th osteotomy	.431	.257	.104

Paired t-test (statistically significant *p* values are emphasized in bold print.

the base measurements to those for the 10th osteotomy, no differences were observed for the NS or AS groups ($p \geq 0.05$), while a significant difference was found for the SP group ($p<0.05$; Table 2, Figure 4).

The study also investigated correlations between the number of osteotomies and the measurements. The only highly positive significant correlation was observed in the SP group ($r=0.990$, $p=0.010$).

DISCUSSIONS

Maintaining surgical instruments is extremely important for surgical quality. The sharpness of an osteotome facilitates work on focused areas, which in turn results in fewer microfractures and prevents unwanted segmental fractures with large volumes

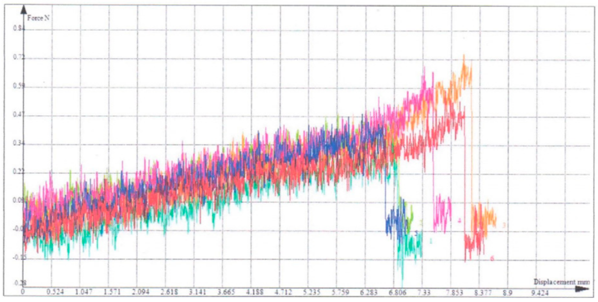

Figure 4: Box plots of sharpness measurements for the groups after the 10th osteotomy and sharpening session

by reducing any unnecessary excessive force on the hammer. In nasal surgery, osteotomes are generally used in hump reduction and lateral osteotomies. A sharp osteotome plays a very important role in achieving the desired result and avoiding complications such as irregularities or asymmetries (2, 4, 5, 8-10).

To date, no consensus has been reached regarding how to measure the sharpness of osteotomes or how often they should be sharpened or replaced after use. Surgeons themselves are the ones who usually decide to sharpen or buy new instruments by palpating with their fingers or sensing its sharpness during an operation (4, 5).

Some authors have tried a variety of methods for determining whether surgical instruments are sharp enough. For instance, Dr. S. Anthony Wolfe stated the best way to ascertain a tool's sharpness is by looking at the light reflectance along its working edge (1). Wolfe's opinion is that a less-sharp edge reflects more light due to the deterioration of the microcrystalline structure of the tool, whereas no light reflects on the sharp edge of a well-sharpened instrument. However, White et al.'s (10) recent article reported that their experimental osteotomy model found visual inspection to be unable to detect blunting of the sharp edge, even when the measured sharpness value had decreased by up to 50%.

More objective tests for measuring sharpness are also commercially available, including the Cutlery and Allied Trades Research Association (CATRA) sharpness tester. This involves a sharpness index that is based on the depths of the first three measurement cuts that are made by pushing the sharp side of a synthetic paper fixed in a station toward the blade while facing up (11). McCarty et al. outlined a blade sharpness index (BSI) as an objective sharpness testing method that forces the osteotome into a soft wax substrate (12). This method also allows for measurement without damaging the fine edge. The current study has preferred using the reliable and reproducible objective method for sharpness as previously been defined by Bloom et al. and Ransom et al. (4, 5).

Many different techniques and sharpening materials are available for maintaining the sharpness of osteotomes. These can be divided into professional sharpening methods using powered instruments and sharpening done with hand tools. When looking at the materials that are used, coarse particulate stones such as aluminum oxide, carborundum, and Norton stones perform the sharpening process quickly but cause a striated appearance along the cutting edge. Arkansas, Neumar, and ceramic stones are examples of fine particle stones that provide sharp-edge softness. In addition, sandpaper can be used as a delicate, easy, and less-expensive sharpening method (13). The recommendations generally involve starting with coarse particle materials and finishing with fine particle sharpeners, which is why this study started sharpening at 500 grit and finished with 1,000 grit for both the SD and AS groups (14).

Manual sharpeners have been observed to possess better cutting edges than those made with powered tools (15, 16). Bloom et al. showed metal mass to decrease quicker with professional sharpening and stated that this situation could decrease the lifespan of the osteotome (4). However, neither professional sharpening nor hand sharpening was able to achieve a result close to the baseline values before the osteotomies.

One thing this study has definitively proven is that osteotomes become dull with use (4, 5). This study found sharpness to gradually decrease in the NS group, with a slight difference being observed between the baseline measurement and the 10^{th} osteotomy/sharpening measurement (p=0.05). Sharpness values continued to deteriorate significantly in the SP group in spite of the sharpening, with a positive and strongly significant correlation between the number of osteotomies and the sharpness measurements (p=0.010, r=0.990). In the AS group, the measurements significantly decreased after the 1^{st} and 4^{th} osteotomies, even though the worst sharpness values among the groups differed significantly at the end of the 4^{th} osteotomy (p<0.05). However, after the 7^{th} and 10^{th} osteotomies the measured change in sharpness decreased significantly, while the significant difference between the NS group's 7^{th} and 10^{th} measurements disappeared (p>0.05). Using a coarse particle sharpener before the osteotome had become dull appears to have resulted in much worse scores in the AS group. As a result of a cumulative effect due to repeated use, the AS group may have started with better scores.

Tebbett recommended sharpening osteotomes after each use (8). Based on the results obtained here, the current study believes that surgeons can use new osteotomes without sharpening them until they feel uncomfortable about their sharpness. Surgeons should also keep in mind the use of disposable osteotomes, as suggested by Bloom et al. (4). However, due to this not always being economically possible, this study believes that using an Arkansas stone in sharpening may provide better long-term results.

The limitation of this study is that, although the measurements were repeated three times, only one osteotome was used in each group. On the other hand, applying forces using a mechanism prevented any possible human-induced measurement variations and provided more objective information, which strengthened the study.

CONCLUSIONS

When considering the complications of a blunt-tipped osteotome, the need for more objective tests regarding the use of osteotomes may be important to note because surgeons cannot easily determine the sharpness of an osteotome, at least not until they use it. However, this study believes that using an osteotome without sharpening it until it becomes dull is better. These can then either be replaced with new ones or professionally sharpened. Sharpening after the first use may damage the cutting edge of the osteotome and blunt the cutting edge. In addition, choosing an Arkansas stone as the sharpening material might be a better choice compared to sandpaper with respect to sharpening.

Ethics Committee Approval: This study was approved by Samsun Training and Research Hospital Clinical Research Ethics Committee (Date: 26.09.2019, No: KAEK 2019/2/24).

Informed Consent: Written informed consent was obtained.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- C.B.; Data Acquisition- M.E.S.; Data Analysis/Interpretation- C.B., N.F.T.; Drafting Manuscript- N.F.T.; Critical Revision of Manuscript- C.B., M.E.S.; Final Approval and Accountability- C.B.; Material or Technical Support- N.F.T., C.B.; Supervision- C.B.

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