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**ORIGINAL INVESTIGATION** **Rhinoplasty**

# Developing the Optimal Osteotome Hand-Sharpening Method

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**Abstract**

**Background:** Rhinoplasty osteotomes can be sharpened in various ways: professional sharpening or hand sharpening using whetstones or rotary powered devices.

**Objective:** To compare the effectiveness of sharpening osteotomes using various sharpening methods with that of professional sharpening as measured by a custom edge tester.

**Materials and Methods:** We performed repeated serial osteotome impacts on bovine femoral cortical bone. These dull osteotomes were sharpened using preidentified sharpening techniques. Edge morphology was evaluated. Sharpness was tested using a custom mechanical testing platform. Optimized sharpness was achieved with a whetstone sharpening method wherein the osteotome is flipped after every stroke.

**Results:** Seven distinct sharpening methods were tested for sharpness five times each to determine the optimal sharpening method versus professional sharpening (control). The two sharpening methods, 5 ($5.51 \pm 0.32$) and 6 ($5.55 \pm 0.32$), that used this flipping technique were significantly sharper than other methods. Methods 5 ($p = 1.0$) and 6 ($p = 1.0$) were the only methods that were not significantly different from control.

**Conclusion:** Single stroke with successively alternating surfaces created the sharpest blades that achieved results similar to professional sharpening.

## Introduction

A sharp blade is essential for precision in various trades from culinary arts to woodcraft. Surgery and rhinoplasty are no exception and the osteotome is an overlooked non-consumable instrument that must be sharp for optimal use. Sharp osteotomes require less force to cut bone and generate cleaner accurate osteotomy lines.[1,2] Dull osteotomes may result in unfavorable fracture patterns and soft tissue injury, as more force is required to drive a blunter surface through tissue.[3,4] Depending on the manufacturer, osteotomes can become dull after as few as three uses.[6] Once dull, a surgeon can manually sharpen

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## KEY POINTS

**Question:** Is hand-sharpening rhinoplasty osteotomes worse than having a professional sharpen them?

**Findings:** Sharpening the osteotome one stroke at a time and flipping to the opposite side of the blade after every stroke created blades that were as sharp as if a professional sharpened them.

**Meaning:** Rhinoplasty surgeons can reliably hand-sharpen osteotomes as sharp as a professional using the method described.

the osteotome with a whetstone, send it to a professional sharpener or the manufacturer for retrofit, or have it replaced.

Surprisingly, professional sharpening is not guaranteed to adequately sharpen an osteotome, as described by Ransom et al. This article advocates that osteotomes could be considered disposable and replaced when they reach a dullness threshold.[6] However, this is not economically feasible and thus many surgeons are forced to decide between professional sharpening or sharpening at the bedside using a whetstone. Most sharpen their osteotomes using techniques acquired during residency; however, literature is sparse on an optimal sharpening method. This study examines the different sharpening methods and identifies techniques that may lead to a sharp osteotome.

We sought to optimize techniques for resharpening osteotomes through careful literature review and by adopting techniques from masters of blade crafts from a variety of fields unrelated to surgery. We hypothesize that osteotomes sharpened with single strokes and alternating surfaces will demonstrate increased sharpness compared with those sharpened using rotary-powered devices or successive sharpening on one side then alternating to the opposite surface, as measured by a custom edge sharpness tester.

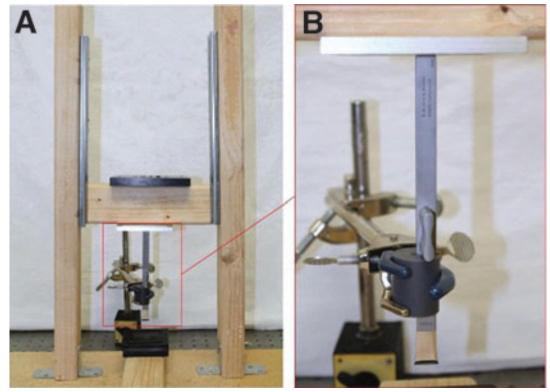


**Fig. 1.** Osteotome holder and setup for dulling protocol. Homemade setup for standardized dulling of osteotome **(A)**. Osteotome was fastened in a 3D printed holder and foam to minimize movement **(B)** and was held by a ring stand. Scrap metal was drilled into the crossbar to provide additional weight to the crossbar and to serve as a solid flat platform for contact upon the osteotome. A drawer mechanism (5 cm full extension side mount ball bearing drawer slide; Everbilt, Atlanta, GA) was utilized for raising weight up to desired standardized height and then released to simulate hammer striking osteotome. 3D, three-dimensional.

## Materials and Methods

### Osteotome testing

Three 10 mm Rubin osteotomes (Black & Black Surgical, Tucker, Georgia) were sharpened by a professional sharpener after arrival from the factory. The osteotome was struck 40 times on bovine cortical bone and tested to measure sharpness. To simulate an osteotome's condition after osteotomy, a device was constructed to hold the osteotome upon bone and apply a standardized ''hit'' upon the osteotome into the compact bone of bovine femur (2.5 cm thick sagittal sections; Fig. 1) that has been equilibrated to ambient temperature. A sliding drawer with a ball-bearing slide mechanism (Everbilt, Atlanta, GA) was vertically oriented to create a guillotine device (Fig. 1A) and was fastened to the laboratory bench top (Fig. 1B).

The osteotome was secured to the mouton using a three-dimensional (3D) printed fastener. Scrap metal was added to the mouton to provide additional mass to the guillotine arm (Fig. 1A). During a standardized ''hit,'' the instantaneous force applied to the osteotomes measured by a load cell was $\sim$500 g, which is consistent with prior reports.[7] ''Dulling'' of a sharp osteotome required 40 standardized ''strikes'' to the osteotome, and after every 5 ''strikes,'' the bone was moved for the osteotome to impact a new location.

A custom edge tester was constructed to quantify the sharpness of each osteotome. The core of the device was a precision mechanical testing platform: the TA Instruments Electroforce 3000 (Newcastle, DE), which allowed generation of force versus displacement curves while the osteotome was compressed against a monofilament fiber (no. 0 polypropylene monofilament-Surgipro™; Covidien, Minneapolis, MN). A suture holder was designed and 3D printed to fasten the polypropylene monofilament to the load cell of the mechanical testing platform (Fig. 2). The suture was secured at one end and then attached to an 888 g weight to standardize tension.

The osteotome was secured to the actuator of the mechanical testing platform using the 3D-printed osteotome

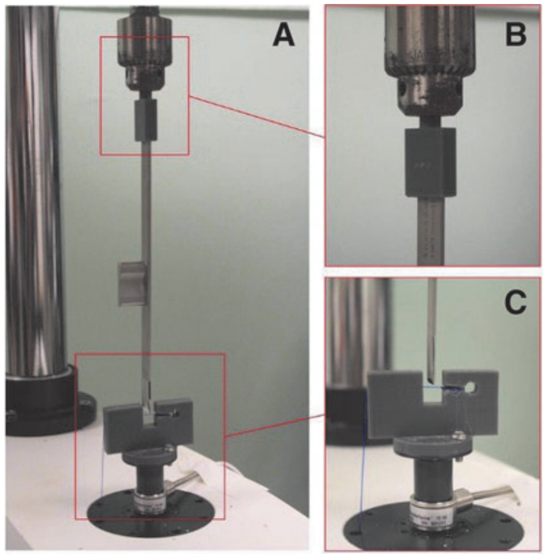


**Fig. 2.** Osteotome holder and setup for testing protocol. Close-up view of the standardized osteotome sharpness testing setup **(A)**. The osteotome was secured into the force tester with a 3D printed jig **(B)**. The sutures were fastened to a suture holder that was 3D printed **(C)** and a weight to provide a standardized material for osteotome cutting.

holder (Figs. 1 and 2) and was vertically displaced, applying increasing force against the suture until the suture was cut. The software (WinTest Version 2.56; TA Instruments) recorded force and displacement as a function of time with a resolution of 0.01 N, 0.001 mm, and 0.05 s, respectively. Translation velocity was 1.5 mm/s until a limit of 6 mm of displacement was reached. The maximum force required to cut the suture was recorded. For each osteotome, sharpness was measured five times along different regions of the osteotome edge.

Osteotomes were sharpened using methods 1–3 shown in Figure 3B and these were labeled as osteotomes 1A, 2A, and 3A in Figure 3A (sharpness from professional sharpening). They were then resharpened by a professional sharpener and tested using methods 4–6 shown in Figure 3B and were labeled as osteotomes 1B, 2B, and 3B in Figure 3A. Sharpness at each time point is defined as the mean force (five trials for each osteotome) necessary to cut a standardized suture.

## Sharpening methods

All osteotomes were initially professionally sharpened as this manufacturer's new devices are shipped dull. Each osteotome was hand sharpened with a moistened fine-grit Black Surgical Arkansas whetstone (Best Sharpening Stones, Tomball, TX). All hand-sharpened osteotomes were sharpened by a single operator (T.V.N.) using the methods described in Table 1. We reached out to >20 senior rhinoplasty surgeons with at least 20 years of experience on their method of whetstone use. Most did not have a consistent technique. We received detailed feedback from three surgeons on their specific techniques that we were able to accurately replicate.

We performed an exhaustive internet survey of how blades are sharpened, and examined the approaches used by chefs, barbers, bladesmiths, hunters, carpenters, sculptors, and butchers.[8–22] This allowed us to formulate three methods with fidelity to these surgeons' approach. The single operator then practiced these three methods: methods 1–3 (Table 1). We also devised new methods 4–6, based on our initial findings (Supplementary Video S1). ''Push'' and ''pull'' are defined in Supplementary Figure S1. An osteotome was sent out to a senior rhinoplasty surgeon who sharpens osteotomes using a rotary knife sharpener and we labeled this as method 0 (RX Honing Machine Corp, Mishakawa, IN).

For comparison, osteotomes were professionally sharpened by a surgical instrument sharpening technician who services seven separate hospital facilities. This sharpening technician utilized a wet grinding wheel without the use of a mandrel and determined adequate blade sharpness based on blade edge feel. These six sharpenings by a professional sharpener were averaged and constituted as baseline professional sharpness.

## Osteotome microscopy

Osteotome blades were imaged using a stereo microscope (SZH; Olympus, Waltham, MA) and 9 MP Microscope Camera (AmScope, Irvine, CA) using image acquisition software (Amlite v2018; Amscope, Irvine, CA) after professional sharpening, dulling, and hand sharpening (Supplementary Fig. S2A–C). We observed edge differences between sharp and dull osteotomes qualitatively.

## Statistical analysis

Statistical analysis was performed on SPSS (v27; IBM, Armonk, NY). Osteotome sharpness was quantified as the force in Newtons required to cut a no. 0 polypropylene monofilament suture. Sharpness was measured at three time points: (1) after professional sharpening, (2) after dulling (40 strikes on cortical bone), and (3) after employing one of the seven sharpening methods given in Table 1. Five trials were performed at each time point for each osteotome. A two-way analysis of variance was conducted to determine the effect of sharpening method on sharpness.

Post hoc analysis with Bonferroni adjustment was performed to identify differences in sharpness across

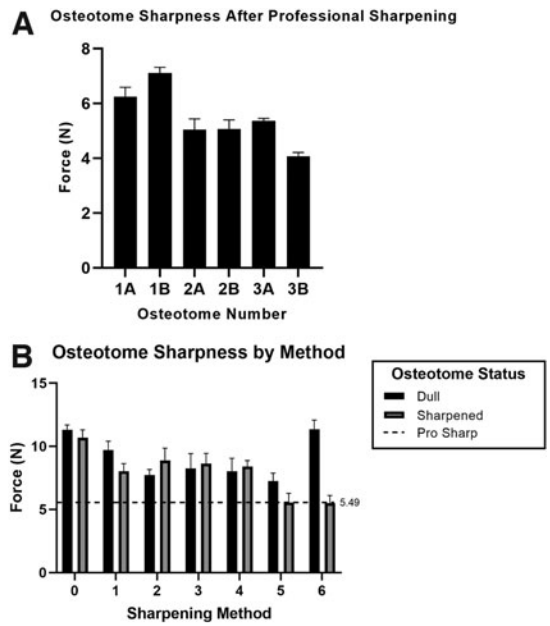


**Fig. 3** **(A)** Osteotome sharpness after professional sharpening. Black bars represent the mean force recorded of professionally sharpened osteotomes. "A" represents the first round of sharpening for the osteotome. "B" represents the osteotomes after they are resharpened and used for another round of testing. There are significant differences between the following pairs of osteotomes: "1A" and "3B" ($p < 0.001$), "1B" and "2A" ($p < 0.001$), "1B" and "2B" ($p < 0.001$), "1B" and "3A" ($p = 0.002$), "1B" and "3B" ($p < 0.001$), and "3A" and "3B" ($p = 0.030$). Values are expressed as mean ± SEM. **(B)** Osteotome sharpness by method. Osteotome sharpness for sharpening methods 0–6 (as described in Table 1). Black bar represents the osteotome's sharpness after they have been dulled, gray bar represents the osteotome's sharpness after they have been sharpened as already described, and the dashed line represents the average sharpness from a professional sharpener (as described in Fig. 3). After hand sharpening, osteotomes using methods 1 ($p = 0.031$), 5 ($p = 0.005$), and 6 ($p < 0.001$) were significantly sharper, when compared with dull. Methods 0, 2, 3, and 4 were not significantly different from dull ($p > 0.05$). When comparing the different sharpening methods with each other, methods 5 (5.51 ± 0.32) and 6 (5.55 ± 0.32) were significantly sharper than all other methods ($p < 0.05$); however, they were not significantly different from each other ($p = 1.0$). Only methods 5 ($p = 0.87$) and 6 ($p = 0.95$) were not significantly different from the professionally sharpened control. Methods 0 ($p < 0.001$), 1 ($p < 0.001$), 2 ($p < 0.001$), 3 ($p < 0.001$), and 4 ($p < 0.001$) were significantly duller than the professionally sharpened control. Values are expressed as mean ± SEM.

the different time points and between the seven sharpening methods. Owing to variability in osteotome sharpness after professional sharpening (Fig. 3A), a one-sample *t*-test was used to determine whether sharpness, after employing one of the seven sharpening methods, was significantly different from mean professional sharpening.

**Table 1. Sharpening methods**

| *Method no.* | *Method description* |
|---|---|
| 0 | Senior rhinoplasty surgeon employed a personal rotary wheel device to sharpen. |
| 1 | Ten forward strokes on each side at a 30° inclination. Then 10 forward strokes on each side with less pressure and a steeper angle of 45°. Then a single light stroke on each side at a 60° inclination. (*Six total flips*) |
| 2 | Forty 1–2 cm swirls at ∼30° inclination. Flip after 20 swirls (*One total flip*) |
| 3 | Forty forward and backward strokes at ∼25–30° inclination. Flip after 20 strokes. (*One total flip*) |
| 4 | Forty backward strokes. Flip after 20 strokes. (*One total flip*) |
| 5 | Forty backward strokes. Flip between each stroke. (No forward stroke/pushing in the direction of the blade tip) (*Forty total flips*) |
| 6 | Twenty forward and 20 backward strokes. Flip after each forward and backward stroke round. (*Twenty total flips*) |

## Results

Baseline sharpness was quantified from three osteotomes sharpened once by the professional (denoted XA) and the same three osteotomes sharpened again by the professional (denoted XB; Fig. 3A). The average sharpness of these six osteotomes is our professionally sharpened control osteotome (6.04 ± 0.3 N). There were significant differences between the following pairs of osteotomes: 1A (6.24 ± 0.35 N) and 3B (7.12 ± 0.20 N; $p < 0.001$), 1B (5.04 ± 0.4 N) and 2A (5.37 ± .09 N; $p < 0.001$), 1B and 2B (5.08 ± 0.33 N; $p < 0.001$), 1B and 3A (4.07 ± 0.14 N; $p = 0.002$), 1B and 3B ($p < 0.001$), and 3A and 3B ($p = 0.030$).

After repeated dulling, sharpness for method 0 was calculated as 11.32 ± 0.17 N, which is a significant increase in force from professionally sharpened control ($p < 0.001$). A similar significant increase in force from baseline after dulling was also observed in methods 1 (9.72 ± 0.30 N, $p < 0.001$), 2 (7.728 ± 0.20 N; $p < 0.001$), 3 (8.27 ± 0.52 N; $p < 0.001$), 4 (8.04 ± 0.45 N; $p < 0.001$), 5 (7.26 ± 0.28 N; $p < 0.001$), and 6 (11.37 ± 0.32 N; $p < 0.001$) (Fig. 3B).

After sharpening using method 0, a sharpness of 10.67 ± 0.26 was measured and found to be not significant from dull ($p = 0.47$). In addition, methods 3 (8.64 ± 0.36;

$p = 1.00$) and 4 ($8.41 \pm 0.20$; $p = 1.00$) were not significantly different from dull after sharpening (Fig. 4). Methods 1 ($8.03 \pm 0.27$ N; $p < 0.001$), 5 ($5.55 \pm 0.33$ N; $p < 0.001$), and 6 ($5.51 \pm 0.27$ N; $p < 0.001$) were significantly sharper than dull. Method 5 was significantly sharper than dull ($p = 0.001$) and significantly sharper than methods 0 ($p < 0.001$), 1 ($p < 0.001$), 2 ($p < 0.001$), 3 ($p < 0.001$), and 4 ($p < 0.001$).

Method 6 was significantly sharper than dull ($p < 0.001$) and significantly sharper than methods 0–4 ($p < 0.001$). Methods 5 and 6 were not significantly sharper or duller than the professionally sharpened control ($p = 0.21$; $p = 0.12$). In addition, methods 5 and 6 were not significantly different from each other ($p = 1.0$; Fig. 4).

## Discussion

Three senior surgeons provided logical and systematic sharpening techniques and an additional senior surgeon sharpened the osteotome with his personal rotary wheel (Table 1). Method 1 was found to be significantly sharper than methods 2 and 3, whereas method 0 was significantly duller than methods 1 and 3. Methods 4–6 were derived from analysis of methods 1–3, and were inspired by what is performed in other industries (Fig. 4).

We found that flipping the osteotome *between each stroke yielded the sharpest osteotome*—sharper than the methods provided by the three rhinoplasty surgeons and similar to a professional sharpener. We compared our method's sharpness with that of a professional sharpener (Fig. 4), finding that our method proved as sharp as the average sharpness of a professionally sharpened osteotome.

Previous studies indicate that osteotomes dull with use and differ in sharpness between manufacturers.[5,6] Bloom et al. show that after use or sharpening by machine or hand, osteotomes are duller than from factory. They advocate that osteotomes should be replaced when a certain dullness threshold is reached. However, they state that professional sharpening extends the life of osteotomes and provides sharper osteotomes than the single hand-sharpening method they employed.[5] Our study looks to extend previous reports and explore hand-sharpening methods that are comparable with professional sharpening and extend the life of osteotomes.

In our study, method 1 differed from the other two methods in two ways: the osteotome was flipped multiple times during sharpening and the blade was only sharpened unidirectionally. Method 1 is similar to the approach used by experts to sharpen straight razors, sushi knives, and hunting knives, all of which experts advocate frequent flipping and unidirectional sharpening with alternating pull strokes of the blade across the sharpening medium. This formed the basis of our other methods, where increasing the number of alternating surfaces during sharpening increased the osteotome sharpness as measured by standardized material cutting.

We used one professional sharpener, who has experience sharpening tens of thousands of surgical instruments, as control because our new osteotomes were found to be shipped rounded and smooth by the manufacturer possibly due to shipping regulations and safety. Our professional sharpener utilized a rotary sharpener as their means of sharpening. Because there is a component of variation even with machine sharpening, there is variability even within a single professional sharpener (Fig. 3A). To minimize this, an entirely automated sharpening technique must be employed. However, differing brand, shape, size, and age of instruments would continue to contribute to variations in sharpness, as even ''factory'' sharpening is done by hand although with a rotary wheel.

We also searched for the ideal means of gauging sharpness. A quantitative approach to evaluate edge dynamics is needed; Ransom et al. looked at osteotome sharpness across different manufacturers. We utilized their method of measuring sharpness through standardized material cutting, which is a practical and reproducible way of evaluating sharpness. This method used a mechanical testing device capable of providing standardized displacement of an osteotome while recording the force applied. However, cutting sutures is very different from cutting bone, the end goal of performing osteotomies.

We acknowledge that this is an inexact metric of sharpness of osteotomes but is a practical surrogate. In addition, we sought a consistent, reproducible, and calibrated means of ''dulling'' the osteotome. Bloom et al.'s work provided a practical, reproducible, and low-cost standardized way to dull an edge. The approach used herein used a guillotine system to which an osteotome was fashioned to produce standardized ''strikes'' against the cortical bone of bovine femur. These standardized hits from this device are not identical to the strikes performed clinically, but is reproducible and highly calibrated.

This approach creates indentations in dense cortical bone, rather than cutting through nasal bone, which is much thinner.[23,24] Clinically, only a part of the osteotome edge traverses bone and the force is variable depending on many factors including strike force, angulation, and grip.[2,25] With standardized dulling, approximately the same force is applied with each strike and is distributed across the entire edge. Regardless, the approach creates a dull osteotome in a reproducible manner.

We believe we have identified a logical approach to guide surgeons in sharpening osteotomes comparable with that achieved using professional sharpening. Flipping after each one to two strokes produces a much sharper blade that is not significantly different from professional sharpening according to our means of measuring sharpness. Performing osteotomies is nuanced as the process is complex and the tissue is heterogeneous depending on the nasal bone that is being fractured and the fracture pattern the surgeon is trying to achieve.[1,2,25]

There were several limitations with this study. First, only one professional sharpener was used. We chose to use one professional sharpener for standardization and understand that this may not be representative of other professional sharpening services. By comparison, edge sharpness trials were performed on osteotomes sharpened by a senior author who had been sharpening his osteotomes with a rotary wheel similar to that used by the professional sharpener. However, these osteotomes sharpened by the surgeon were less sharp than that of the professional sharpener and of our hand-sharpening method.

Further studies will be performed to compare the quality of different professional sharpeners. Another question that arises is whether osteotomes should be replaced rather than sharpened, given previous studies have shown there is a duty life to osteotomes.[5] The osteotomes used here were purchased and shipped dull from an industry-leading manufacturer requiring sharpening before use. Therefore, we did not have a factory-sharpened osteotome at baseline that would allow us to adequately address this. In addition, some hospital systems do not allow whetstones in surgical trays and, in those cases, would require sharpening osteotomes outside of the operating room and sending them to sterile processing or employing a professional sharpener.

We also used an extra-fine grit Arkansas stone due to its ubiquity in surgical equipment sharpening and further studies can be done to explore the effects of different types of stones on sharpness.[26] Lastly, we used a Rubin type osteotome due to the simplicity of the profile and shape. However, we did not explore our sharpening method on the gamut of more complex osteotome shapes such as guarded, Cinelli, and curved osteotomes (i.e., chisels). As such, these data must be interpreted in the context of the study design and future studies should be conducted to explore different factors affecting osteotome sharpness.

There are multiple factors that go into a successful and accurate osteotomy including instrument sharpness, the selection of devices for the type of osteotomy, and execution by a skilled surgeon.[25] Out of these factors, only instrument sharpness can be changed. We have found a method that produces a sharper instrument. Although we were able to achieve sharpness equivalent to professional sharpening through a simple technique change, we believe there is still a wealth of information on sharpening that is unexplored and has not been applied to the art of osteotomy.

## Conclusion

Osteotome sharpening techniques have undergone little scrutiny or systematic analysis in the literature. Some studies have suggested that osteotomes should be discarded once dull. We believe we have found an optimal hand-sharpening method with single strokes and successively alternating surfaces, which achieved similar results to professional sharpening.

## Authors' Contributions

Conception and design of study were done by T.V.N., A.C.P., K.H.A., B.J.F.W., A.-J.T., N.P., T.A.C., and J.-H.M. Acquisition of data was carried out by T.V.N., A.C.P., K.H.A., K.H., M.V., K.K.D., and N.S. Analysis and/or interpretation of data were carried out by T.V.N., A.C.P., K.H.A., K.H., M.V., K.K.D., N.S., and B.J.F.W. Drafting the article was done by T.V.N., A.C.P., K.H.A., K.H., M.V., K.K.D., N.S., and B.J.F.W. Revising the article critically for important intellectual content was done by T.V.N., A.C.P., K.H.A., K.H., M.V., K.K.D., N.S., and B.J.F.W.

## Author Disclosure Statement

No competing financial interests exist.

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## Supplementary Material

Supplementary Figure S1
Supplementary Figure S2
Supplementary Video S1

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