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# A Comparison of Intraoperative Metrics between the Infiniti with and the Centurion without Intelligent Phacoemulsification Systems

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## Abstract

**Purpose:** To compare the efficiency and safety of two phacoemulsification systems, the Infiniti with intelligent phacoemulsification (IP) and the Centurion without IP, in terms of intraoperative metrics of phacoemulsification and the occurrences of adverse events and intraoperative tip obstruction.

**Design:** Comparative case series.

**Methods:** A consecutive series of 340 eyes (151 eyes with the Infiniti, 189 eyes with the Centurion) was evaluated. A 2.4 mm sclerocorneal incision was used with the Infiniti, and a 2.0 mm incision was used with the Centurion. Phacoemulsification of the nucleus was performed using the phaco chop technique, with the IP function of the Infiniti turned on and the IP mode of the Centurion turned off. From among the parameters displayed on the panels of both devices, ultrasound (US) time, cumulative dissipated energy (CDE), aspiration time, and estimated balanced salt solution (BSS) aspiration volume were investigated and compared between the devices. Results: A comparison of all subjects found significant differences between the two devices in mean CDE ( $p=0.02$ ) and mean aspiration time ( $p=0.003$ ), but not in mean US time ( $p=0.43$ ) or mean estimated BSS aspiration volume ( $p=0.07$ ). For grade 3 nuclei, all parameters of mean US time ( $p=0.0044$ ), mean CDE ( $p \leq 0.001$ ), mean aspiration time ( $p < 0.001$ ), and mean estimated BSS aspiration volume ( $p=0.001$ ) showed significant differences favoring the Centurion.

**Conclusions:** Compared to the Infiniti with IP mode, cataract surgery with the Centurion without IP mode is likely to be performed with less phacoemulsification energy and higher efficiency.

**Keywords:**

Centurion; Infiniti; Intelligent Phacoemulsification Mode; Ultrasound time; Cumulative dissipated energy

## Introduction

In recent years, remarkable advances have been made in phacoemulsifier (phaco) devices for use in cataract surgery, enabling the insertion of ultrasound (US) tips and sleeves *via* microincisions, improving anterior chamber stability, and increasing surgical efficiency even with low phaco power output during nuclear phacoemulsification [1-4]. The Infiniti® Vision System platform (Alcon Laboratories, Inc., Fort Worth, TX, USA) (hereinafter Infiniti) enables torsional phacoemulsification with the Ozil® handpiece in addition to conventional longitudinal phacoemulsification [5,6]. Torsional phacoemulsification produces rotary and side-to-side oscillatory movement of the phaco tip to remove lens material by surface shearing with minimal repulsion of lens material to perform nuclear phacoemulsification more efficiently [5,6]. However, fragments of nucleus sometimes became clogged inside the phaco tip [5,7]. Then, the Ozil® Intelligent Phaco (IP) software was added to the Infiniti in 2009 [5]. If the vacuum pressure rises to a level above that set by the surgeon during nuclear phacoemulsification, the IP software automatically switches the device to short pulses of longitudinal phacoemulsification to prevent nuclear fragments from becoming stuck. Since the incidence of tip obstruction thus becomes extremely low, it is common to set the Infiniti with IP mode under pure torsional ultrasound. The Centurion® Vision System platform (Alcon Laboratories, Inc.) (here in after Centurion) is an active-fluid configuration that has been developed as the successor to the Infiniti. Different from the Infiniti with a gravity-fluid configuration, the Centurion is capable of maintaining intraocular pressure at the selected level to improve the intraoperative stability of the anterior chamber. The Centurion has new Balanced Energy™ technology and now enables efficient nuclear phacoemulsification at lower power output. The Centurion is being widely used with its IP mode as the Infiniti is, as well as with the INTREPID® balanced tip, as

recommended by the manufacturer [6]. Many clinical results showing better efficiency for the Centurion with these configurations have been reported to date [8,9]. These results might suggest that the further improved efficiency of shearing lens materials might make the IP mode unnecessary during nuclear phacoemulsification with the Centurion. However, no data have yet been obtained regarding the intraoperative metrics for the Centurion without IP mode. Therefore, a comparative case series study was performed to investigate the intraoperative metrics with the Infiniti with IP mode and the Centurion without IP mode under pure torsional power. Furthermore, the occurrence of tip obstruction was compared between these two methods.

## Subjects and Methods

A consecutive series of 340 eyes (169 males and 171 females, 173 right eyes and 167 left eyes) that underwent cataract surgery conducted by the same experienced surgeon (SA) between December 2015 and May 2016 was evaluated. The nuclear grade was determined according to the findings of the first chop during nuclear fragmentation. If the nucleus was too soft to split, it was graded 1 or 2, if it could be split easily, it was graded 3, and if it was so hard that the base did not split, it was graded 4 or 5 [7]. With both devices, the procedure was performed *via* a sclerocorneal incision, with a width of 2.4 mm for the Infiniti and 2.0 mm for the Centurion. After a viscoelastic substance had been injected, a cystotome needle was used to complete anterior circular capsulotomy. Hydrodissection and hydrodelineation were then performed, and the nucleus was segmented using the phaco chop technique. The cortex was then aspirated by infusion/aspiration (IA), followed by injection of sufficient viscoelastic substance and the insertion of an acrylic intraocular lens (IOL) into the capsular bag. Finally, the viscoelastic substance was removed by IA. After self-closure of the wound had been confirmed, the operation was concluded. After the phacoemulsification, from among the intraoperative metrics displayed on the panels of both devices, ultrasound (US) time, cumulative dissipated energy (CDE), aspiration time, and estimated balanced salt solution (BSS) aspiration volume were investigated and compared between the devices. Intraoperative complications and the occurrence rate of tip obstruction by fragments of the nucleus were also investigated.

US time is the total time in seconds during which the foot pedal is kept in the third position. CDE means the amount of US energy used during the procedure, and it is measured in different ways for longitudinal phacoemulsification and torsional phacoemulsification. If the procedure is performed using pure longitudinal phacoemulsification, it is calculated as mean longitudinal power  $\times$  total phacoemulsification time. For pure torsional phacoemulsification, it is calculated as mean torsional power  $\times$  0.4  $\times$  total phacoemulsification time. The stroke distance is 90  $\mu$ m in longitudinal phacoemulsification and 45  $\mu$ m

in torsional phacoemulsification, with the latter only half that of the former. The frequency is 40,000 Hz in longitudinal phacoemulsification and 32,000 Hz in torsional phacoemulsification, with the latter only 80% of the former. This means that the energy used in torsional phacoemulsification is 40% of that used in longitudinal phacoemulsification for the same number of oscillations, and a coefficient of 0.4 is therefore used (Data from Alcon Laboratory 2015). When a combination of longitudinal and torsional phacoemulsification is used, the CDE is calculated as the sum of the two types.

The settings for the parameters in each of the two cataract surgery devices were as follows.

For the Infiniti: bottle height 92 cm, aspiration/flow rate 40 mL/min, vacuum level 400 mmHg, continuous mode, torsional power 70%, dynamic rise 2, IP on (initiating 10-ms longitudinal phacoemulsification if the vacuum level rises to 95%), with an Intrepid<sup>®</sup> Ultra sleeve fitted to a 0.9 mm 45-degree bevel Kelman ultrasound tip attached to an Ozil torsional handpiece were used. IA was performed with vacuum pressure of 575 mmHg and a flow rate of 25 mL/min.

For the Centurion: IOP ramp Fast, irrigation factor 1.6, IOP 70 mmHg, aspiration flow rate 35–40–35 mL/min, vacuum level 350–400 mmHg, continuous torsional linear phacoemulsification, torsional power 70%, vacuum rise 0, IP off, with a 0.9-mm Intrepid<sup>®</sup> Nano sleeve fitted to a 0.8-mm 45-degree bevel balanced ultrasound tip were used. IA was performed with IOP of 60 mmHg, vacuum pressure of 600 mmHg, and a flow rate of 35 mL/min.

For statistical analysis, the Shapiro-Wilk test was used to evaluate the normality of the populations. A nonparametric procedure was used to compare the distributions of the data between the two groups using the Mann-Whitney U test. Two-way ANOVA was performed when categorical variables of cataract grades were included. A p-value less than 0.05 was regarded as significant. The statistical software was SPSS 13.0 (SPSS Inc, Chicago, IL).

Informed consent was obtained from all participants, and the study was reviewed and approved by the ethics committee at our institution.

## Result

The Infiniti was used to treat 151 eyes of 151 patients (72 males and 79 females, 79 right eyes and 72 left eyes); the mean age of these subjects was  $74.6 \pm 10.2$  years (range 31–94 years). The Centurion was used for 189 eyes of 189 patients (97 males and 92 females, 94 right eyes and 95 left eyes); the mean age of these subjects was  $72.8 \pm 11.9$  years (range 15–93 years), with no significant differences in age ( $p=0.20$ ), sex ( $p=0.56$ ), or laterality ( $p=0.68$ ) between the two device groups (**Table 1**).

**Table 1:** Demographic characteristics of the patients; SD, standard deviation.

Nuclear density	Eye (right/left)		Sex (female/male)		Age (y), mean ± SD	
	Infiniti	Centurion	Infiniti	Centurion	Infiniti	Centurion
Grade 1	2-Feb	3-Feb	1-Mar	4-Jan	42.5 ± 8.0	29.8 ± 13.0
Grade 2	5-Jun	1-Jul	9-Feb	4-Apr	64.7 ± 12.0	55.3 ± 8.1
Grade 3	68/58	65/73	70/56	69/69	76.1 ± 7.8	73.9 ± 8.2
Grade 4	7-Feb	18/16	5-Apr	16/18	78.9 ± 7.3	77.5 ± 10.0
Grade 5	Jan-00	2-Feb	0/1	2-Feb	88	84.0 ± 5.7

### Number of eyes with various nucleus grades

Of the 151 eyes treated with the Infiniti, 4 eyes were nuclear grade 1, 11 were grade 2, 126 were grade 3, 9 were grade 4, and 1 was grade 5. Of the 189 eyes treated with the Centurion, 5 were nuclear grade 1, 8 were grade 2, 138 were grade 3, 34 were grade 4, and 4 were grade 5 (Table 2).

**Table 2:** Comparison of intraoperative metrics between the Infiniti and the Centurion for different grades.

	Infiniti	Centurion	p value
Age (y), mean ± SD	74.6 ± 10.2	72.8 ± 11.9	0.2
Range	31-94	15-93	
Sex (female/male)	79/72	92/97	0.56
Eye (right/left)	79/72	94/95	0.68

There was no significant difference in the distribution of nuclear grades between the two device groups ( $p=0.68$ ). Nuclear grade 1 and grade 5 eyes were excluded from the analysis, because the numbers of eyes with these grades were small.

### Comparison of mean intraoperative parameters by cataract grade with each phaco device

Mean US time ( $p=0.008$ ), mean CDE ( $p=0.02$ ), mean aspiration time ( $p=0.0001$ ), and mean estimated BSS aspiration volume ( $p=0.0002$ ) were increased in order of cataract grade from grade 2 to grade 4 with the Centurion and the Infiniti. These data suggested that the lenses became harder in order of cataract grade in the present patients.

### Comparison of mean intraoperative parameters between the two device groups including all cataract grades from grades 2 to 4

Mean US time was  $30.7 \pm 15.5$  s for the Infiniti and  $29.4 \pm 13.4$  s for the Centurion, with no significant difference between the two devices ( $p=0.43$ ). Mean CDE was  $5.76 \pm 3.89$  s for the Infiniti and  $4.80 \pm 2.77$  for the Centurion, with a significant difference between the two devices ( $p=0.02$ ). Mean aspiration time was  $121.3 \pm 47.9$  s for the Infiniti and  $109.7 \pm 41.0$  s for the Centurion, with a significant difference between the two devices ( $p=0.003$ ). Mean estimated BSS aspiration volume was  $38.4 \pm 12.9$  mL for the Infiniti and  $36.6 \pm 12.4$  mL for the Centurion,

with no significant difference between the two devices ( $p=0.07$ ) (Table 3).

**Table 3:** Comparison of intraoperative metrics between the Infiniti and the Centurion for nuclear grades 2-4.

Grades 2-4	Infiniti	Centurion	p value
Number of eyes	146	180	
Mean US time (s)	$30.7 \pm 15.5$	$29.4 \pm 13.4$	0.43
Mean CDE (s)	$5.76 \pm 3.89$	$4.80 \pm 2.77$	0.02
Mean aspiration time (s)	$121.3 \pm 47.9$	$109.7 \pm 41.0$	0.003
Estimated fluid usage (mL)	$38.4 \pm 12.9$	$36.6 \pm 12.4$	0.07
CDE, cumulative dissipated energy; US, ultrasound			

### Comparison of mean intraoperative parameters between the two device groups by cataract grade

For grade 2, there were no significant differences in US time ( $p=0.41$ ) and aspiration time ( $p=0.30$ ) between the Infiniti and the Centurion. CDE was less for the Centurion, but the difference was not significant ( $p=0.08$ ). Only estimated BSS aspiration volume was significantly lower ( $p=0.048$ ) for the Centurion (Table 4).

**Table 4:** Comparison of intraoperative metrics between the Infiniti and the Centurion for nuclear grade 2.

Grade 2	Infiniti	Centurion	p value
Number of eyes	11	8	
Mean US time (s)	$17.2 \pm 10.3$	$12.7 \pm 2.2$	0.41
Mean CDE (s)	$1.90 \pm 0.86$	$1.23 \pm 0.41$	0.08
Mean aspiration time (s)	$118.2 \pm 58.8$	$106.0 \pm 64.5$	0.3
Estimated fluid usage (mL)	$39.6 \pm 18.2$	$28.3 \pm 4.1$	0.048
CDE, cumulative dissipated energy; US, ultrasound			

The cataract grade 3 group showed significantly smaller values for all of US time ( $p=0.0044$ ), CDE ( $p<0.001$ ), aspiration time

( $p < 0.001$ ), and estimated BSS aspiration volume ( $p = 0.001$ ) for the Centurion (Table 5).

**Table 5:** Comparison of intraoperative metrics between the Infiniti and the Centurion for nuclear grade 3.

Grade 3	Infiniti	Centurion	p value
Number of eyes	126	138	
Mean US time (s)	29.7 ± 11.9	25.7 ± 8.8	0.004
Mean CDE (s)	5.47 ± 2.80	3.94 ± 1.55	<0.001
Mean aspiration time (s)	115.4 ± 38.4	97.4 ± 28.3	<0.001
Estimated fluid usage (mL)	36.8 ± 11.2	33.5 ± 10.0	0.001
CDE, cumulative dissipated energy; US, ultrasound			

Grade 4 CDE ( $p = 0.003$ ) and aspiration time ( $p = 0.03$ ) were significantly lower with the Centurion. US time and estimated BSS aspiration volume were smaller with the Centurion, but the differences were not significant (Table 6).

**Table 6:** Comparison of intraoperative metrics between the Infiniti and the Centurion for nuclear grade 4.

Grade 3	Infiniti	Centurion	p value
Number of eyes	9	34	
Mean US time (s)	61.9 ± 24.7	48.5 ± 12.3	0.09
Mean CDE (s)	14.52 ± 6.57	9.11 ± 2.51	0.003
Mean aspiration time (s)	207.4 ± 72.0	159.7 ± 41.2	0.03
Estimated fluid usage (mL)	59.1 ± 10.7	51.1 ± 11.9	0.07
CDE, cumulative dissipated energy; US, ultrasound			

No intraoperative complications occurred, and no case developed complete clogging of the tip by nuclear fragments with both devices.

## Discussion

Previous comparisons of US time and CDE before IP mode showed that both were significantly decreased with pure torsional phacoemulsification for all grades of cataracts [1] and for grade 2 and 3 cataracts [10] when compared with pure longitudinal phacoemulsification with the Infiniti, although other studies found no significant differences [11]. A comparison between the use of pure torsional phacoemulsification and mixed torsional and longitudinal phacoemulsification also found that US time was significantly shorter with pure torsional phacoemulsification for cataracts classified as grade 3 or 4, with significantly lower CDE for grade 4 cataracts [12]. There is again a conflicting report that a significant difference was present in CDE with torsional phacoemulsification for cataracts with grades 1, 2, and 3, but not with grade 4 [13]. After IP mode was developed as new power-delivery software to reduce obstruction of the tip during torsional phacoemulsification with

the Infiniti, comparisons between with and without IP mode were made. A significant difference was seen in CDE only for grade 4 cataracts [14], but two other reports showed no significant difference in CDE for any grade of cataracts [8,9]. However, there were significant differences in total occlusion time and the longest occlusive event for grade 3 and 4 cataracts, favouring torsional phacoemulsification with IP mode [8]. Thus, it became common to set the Infiniti to IP mode under pure torsional phacoemulsification. A further innovation was made to introduce an Intrepid Balanced tip for Ozil phaco handpieces with a 50% enhancement in sideways tip displacement (Data from Alcon Laboratories, 2015). Torsional phacoemulsification with the balanced tip showed significantly less US time and CDE than with the mini-flared Kelman tip, with both using the Infiniti with IP mode [6]. Recent studies that were similar to the present one compared intraoperative parameters between torsional phacoemulsification with the Infiniti with a mini-flared Kelman tip and with the Centurion with an Intrepid balanced tip, both without mention of the use of IP mode, and they showed significant reductions of CDE, aspiration fluid volume, and aspiration time [8,9].

In the present study, comparison of intraoperative parameters between the Infiniti with a mini-flared Kelman tip and IP mode on and the Centurion with an Intrepid balanced tip and IP mode off for all cataracts, including grades 2 to 4, showed that overall US time was similar ( $p = 0.43$ ), but CDE ( $p = 0.02$ ) was significantly smaller with the Centurion than with the Infiniti. Since the ultrasound energy used in torsional phacoemulsification is 40% of that used in longitudinal phacoemulsification for the same number of oscillations (Data from Alcon Laboratory 2015), the pulses of the additional longitudinal phacoemulsification by IP mode discharged more ultrasound energy than torsional phacoemulsification per unit time. Thus, CDE with the Centurion became lower than with the Infiniti when the US time was similar. Aspiration time was significantly shorter with the Centurion ( $p = 0.003$ ), but estimated BSS aspiration volume was not significantly different ( $p = 0.07$ ). Estimated BSS aspiration volume is calculated on the basis of the time for which the peristaltic pump is in operation, whereas the aspiration time is counted as the time even when the pump is closed (Data from Alcon Laboratory 2015). This suggested that the closed time may have been shorter when the Centurion was used compared with the Infiniti, significantly reducing the aspiration time, but that the total time for which the peristaltic pump was actually in operation was the same, accounting for the lack or the reduction of change in the estimated BSS aspiration volume.

When the intraoperative parameters were compared separately by cataract grade between the two device groups, the efficiency of the Centurion without IP mode became apparent. For grade 2 cataracts, since the lens nuclei were so soft, the IP mode of the Infiniti might have worked less frequently than for grade 3 cataracts. Thus, there were no significant differences in US time ( $p = 0.41$ ), UDE ( $p = 0.08$ ), and aspiration time ( $p = 0.30$ ) between the two devices.

For grade 3 cataracts, all of the parameters, US time ( $p = 0.0044$ ), CDE ( $p < 0.001$ ), aspiration time ( $p < 0.001$ ), and estimated BSS volume use ( $p = 0.001$ ), were lower with the

Centurion than with the Infiniti. Thus, pure torsional phacoemulsification with the Centurion without IP is more efficient and safer for grade 3 cataracts than torsional phacoemulsification associated with pulses of longitudinal phacoemulsification with the Infiniti with IP.

For grade 4 cataracts, it took as much time for the Centurion without IP mode to complete phacoemulsification as for the Infiniti with IP mode ( $p=0.09$ ). However, CDE with the Centurion was lower than with the Infiniti ( $p=0.003$ ) due to the absence of longitudinal ultrasound pulses with IP mode. As mentioned earlier, the longer aspiration time with the Infiniti than with the Centurion ( $p=0.03$ ) and the similar estimated BSS volume ( $p=0.07$ ) indicated occasions of the IP mode working with the Infiniti.

The present study showed that there was no clear difference in the efficiency of phacoemulsification for soft lens materials of grade 2 cataracts between the Centurion without IP mode and the Infiniti with IP mode in terms of CDE. However, the difference in CDE became apparent for harder cataracts of grades 3 and 4. The lower CDE with Centurion without IP mode may mean less ultrasound energy dissipated in the anterior chamber to impose less stress on the corneal endothelium and the incisional wound than with Infiniti with IP mode, although pre- and post-operative examinations of corneal endothelial cell density and corneal thickness were not performed in the present study.

The present study is limited in several respects. First, it was a consecutive case series study, and although the same surgeon performed all of the surgeries, the two methods were not randomized and were examined over different durations. Second, the number of total eyes was limited, and the numbers of eyes with grade 2 and 4 cataracts were small. Thus, a direct comparison is awaited in a randomized manner between pure torsional phacoemulsification with the Centurion without IP mode and combined torsional and longitudinal phacoemulsification with the Centurion with IP mode, in particular for hard cataract lenses of grades 4 and 5.

The IP mode for the phacoemulsification system was initially developed in order to decrease the risk of tip obstruction with nuclear fragments, and the use of IP mode with the Centurion as with the Infiniti has been widely adopted as today's standard. In the present study, the occurrence of tip obstruction was investigated along with intraoperative metrics for surgery with the Centurion without IP mode, showing that no nuclear fragments completely obstructed the tip for grade 4 and grade 5 nuclei. Moreover, this usage showed data that might be taken as a significant advantage over the Infiniti with IP mode, namely the lower CDE for the grade 2, 3, and 4 nuclei compared to operation with the Infiniti with IP mode. In terms of the cataract surgery with the minimal phacoemulsification energy with the maximal efficiency, the procedure with pure torsional phacoemulsification using the Centurion might be the ideal current method to achieve this strategy. Thus, we propose the use of the Centurion without IP mode, namely without the use of longitudinal phacoemulsification, for the entire procedure.

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