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Derleme / Review

Torsional Phacoemulsification and Tip Selection

Torsiyonel Fakoemülsifikasyon ve Fako İğnesi Seçimi

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Summary
One of the recent advances in cataract surgery is torsional phacoemulsification. It was developed to increase the efficacy of ultrasonic emulsification. In torsional phacoemulsification, the torsional movement of the tip is translated to side-to-side cutting action with the aid of bent phaco tips. Lens material is cut in both directions, rather than only during a forward stroke. The efficiency of this technique is further enhanced by an improvement in followability provided by the inherent non-repulsive nature of the side-to-side motion. Tip selection is very important for the efficiency of torsional phacoemulsification. Theoretically, there are 2 ways to enhance the cutting efficiency of the tip. First is the stroke length; the 22-degree bent 30-degree Kelman mini-flared tip cuts longer than the 12-degree bent 30-degree mini-flared Kelman tip. Second is the angulation or bevel; the higher the degree (45 degrees), the better cutting efficiency. Retrospective analyses of the previously published clinical studies clearly demonstrated that the efficacy of the torsional phacoemulsification has positive correlation with both the aperture angles and neck angles of the tips. (Turk J Ophthalmol 2014; 44: 392-5)
Key Words: Torsional phacoemulsification, phaco tips

Özet
Torsiyonel fakoemülsifikasyon katarakt cerrahisindeki son gelişmelerden biridir. Ultrasonik emülsifikasyonun verimini arttırmak için geliştirilmiştir. Torsiyonel fakoemülsifikasyonda, iğnenin torsiyonel hareketi eğimli fako iğnelerinin yardımı ile yandan yana kesme hareketine dönüşür. Sadece ileri vuruş yerine lens her iki yöndeki hareket esnasında da kesilir. Yatay kesme hareketinin tabiatında itme olmamasından dolayı daha iyi takip sağlanabilir, bu da tekniğin verimini daha da arttırmaktadır. Torsiyonel fakoemülsifikasyonun verimi için iğne seçimi çok önemlidir. İğnelerin kesme verimini teorik olarak arttırmanın iki yolu bulunmaktadır. Birincisi darbe uzunluğudur; 22 derece eğimli, 30 derece açıklı iğne, 12 derece eğimli 30 derece açıklı iğneden daha uzun bir kesim hareketine sahiptir. İkincisi ise ağız açıklık açısıdır. Ne kadar fazla (45 derece) ise kesme etkisi de o kadar fazladır. Torsiyonel fakoemülsifikasyonun verimliliği ile iğnelerin hem boyun açıları hem de açıklık açıları arasında pozitif ilgileşim olduğu daha önceden yayınlanan klinik çalışmaların analizleri ile açıkça gösterilmektedir. (Turk J Ophthalmol 2014; 44: 392-5)
Anahtar Kelimeler: Torsiyonel fakoemülsifikasyon, fako iğneleri

Introduction

One of the most important surgical interventions of an ophthalmologist is cataract surgery. The main surgical option for elective cataract surgery is phacoemulsification, which has allowed surgeons to perform small incision cataract operations with good outcomes.[1,2] Although there have been significant advances in technique and technology of emulsification, such as interrupted phaco modes, improved pump systems, nucleofractis techniques, and vacuum-assisted phaco, it still carries risk of injury to delicate ocular structures such as corneal endothelium.[3,4]

In conventional longitudinal phacoemulsification, emulsification occurs by the forward and backward movement of the tip. The energy is delivered directly to the nucleus by the forward movement of the tip which is also called the active part of the cycles. But same energy is also delivered to the eye during the backward movement. This passive part of the cycles creates no effective cutting but friction and heat production still

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continues. The forward kick could also cause repulsion of the lens material especially if the vacuum is not strong enough to hold the fragments.[5]

The action of phacoemulsification can include several mechanisms including direct mechanical cutting, termed the jackhammer effect, and implosion of microcavitation bubbles.[6] To avoid the handicaps of the jackhammer effect, a new torsional emulsification motion which emulsifies the lens by shearing action was developed. In January 2006, Alcon Surgical incorporated Ozil torsional into the Infiniti Vision System. In torsional phacoemulsification, the torsional movement of the tip is translated to side-to-side cutting action with the aid of bent phaco tips. Ozil torsional phaco is more efficient than traditional longitudinal phaco because of its side-to-side oscillatory shearing action. Lens material is cut in both directions, rather than only during a forward stroke. The efficiency of this technique is further enhanced by an improvement in followability provided by the inherent non-repulsive nature of the side-to-side motion. The tip moves at a frequency of 32 kHz in torsional phacoemulsification.[5] The lower frequency was also supposed to reduce the heat signature over that created with traditional ultrasound (US) at 40 kHz.[7] Theoretically, torsional phaco increases cutting efficiency, improves the followability and decreases the dispersion of lens material, reduces fluid usage, and reduces the risk of thermal injury by reducing the frictional movements within the incision and by lowering the frequency.

Experimental and clinical studies were performed to demonstrate these advantages of torsional phaco. Liu et al.[5] compared torsional and conventional longitudinal-mode phacoemulsification and found that less cumulative dissipated energy (CDE) was used in the torsional group at all grades of nucleus density. Also, the torsional mode had a better visual outcome in the early postoperative phase of the study. Davison[8] used straight and angled tips in longitudinal and torsional phacoemulsification and as a conclusion, torsional phacoemulsification using an angled tip required less surgeon-generated tip travel and less time, suggesting that nuclear material may be more efficiently approximated to and aspirated through the tip aperture throughout the phacoemulsification process. Oakey et al.[9] used porcine lens nuclei as a model for comparison of 3 US modalities regarding efficiency and chatter. No statistically significant difference was observed between the groups and longitudinal US was found to be an acceptable alternative to torsional and transversal US. In an experimental study by Miyoshi et al.[10] increased efficiency with ongoing emulsification in both lateral strikes and multiple points of cavitations were pointed as the important superiorities of torsional over longitudinal phacoemulsification.

Followability and lack of repulsion were important advantages of torsional phaco. Wang et al.[11] demonstrated that torsional phacoemulsification could be performed more efficiently with higher vacuum levels. Fernandez de Castro et al.[12] developed a bead-flow pattern for visualizing and comparatively quantifying the fluid movement using a torsional or longitudinal US phaco handpiece. Bead clearance time was approximately 50% faster with torsional than with longitudinal US, regardless of the power setting in their study.

Heat production, which can lead to wound burn and have potential to damage intraocular structures, is an important handicap of emulsification. In the experimental study by Han et al.[13], heat productions of longitudinal and torsional phacoemulsification were compared. A straight 30-degree non-aspiration bypass system (ABS) microtip on an Infiniti US handpiece (Alcon, Inc.) and a 45-degree Kelman mini-flared ABS tip on an OZil torsional handpiece (Alcon, Inc.) were used. Continuous US in longitudinal or in torsional mode with same power, same stroke length, or with same applied energy were compared. Torsional phacoemulsification generated less heat than longitudinal phacoemulsification in all 3 comparison tests. In the experimental study by Jun et al.[14], incision temperatures of torsional and longitudinal US using 2.75 mm or 2.20 mm incisions were compared. A 0.9 mm 30-degree Kelman turbosonic miniflared aspiration bypass tip with a 0.9 mm Microsmooth MicroTip infusion sleeve or Microsmooth Ultra infusion sleeve (Alcon, Inc.) were used in 100% longitudinal or torsional power. Incision temperature was influenced by US modality and was significantly lower with torsional US than with longitudinal US.

Reuschel et al.[15] conducted a clinical study to show endothelial cell changes after torsional and longitudinal phacoemulsification. Although the mean US time, CDE, and percentage total equivalent power imposition 3 were statistically significantly lower in the torsional group than in the longitudinal group, similar endothelial cell density changes were observed in both groups.

The effectiveness of phacoemulsification depends on the proportion of applied US energy and fluid exchange in the anterior chamber during the removal of nuclear material.[9] The major handicap of the torsional phacoemulsification which decreases the efficacy of the emulsification is clogging. It is the obstruction of the tip's shaft by emulsified nucleus material, mostly seen in the emulsification of dense cataracts and especially if 0.9 mm tips are used. When clogging happens, optimal shearing plane is lost and ineffective US energy is delivered since the obstructed tip does not allow aspiration of the emulsified nucleus materials. To overcome this handicap, surgeons add longitudinal component to the torsional movement. In the study by Rekas et al.[16], longitudinal 20% power was added to torsional phaco in hard cataracts to avoid clogging. Intelligent Phaco (IP) upgrade which delivers a very small amount (short pulse) of longitudinal US just after reaching the preset maximum vacuum level was combined with torsional technology to further increase its efficiency. Risk of clogging and shifts in the IOP decrease, and the eye is maintained in a more natural state throughout the surgery, theoretically, with the IP upgrade.

Ratnarajan et al.[17] and Cionni et al.[18] conducted a study comparing the outcomes of torsional phacoemulsification with or without the IP upgrade. A 30-degree Kelman-style mini-flared phaco tip was used in both studies. Significantly reduced CDE, foot pedal 3 times, balanced salt solution (BSS) volume, and shorter durations of occlusive events during surgery were observed with the upgrade.

We had also conducted a study to compare the safety and efficacy of microcoaxial phacoemulsification surgeries performed with the Ozil IP torsional mode and combined torsional/longitudinal US mode. A 0.9-mm 30-degree mini-flared 12-degree bent tip was used in all of the operations. Although lower CDE values were found in the IP group, statistical significance could not be achieved. Ozil IP torsional mode provided more effective lens removal than the combined torsional/longitudinal US mode with a statistically significant lower UST and volume of BSS used.[19] IP was introduced in order to facilitate the lateral movement in lens material emulsification avoiding the complete tip occlusion. The longitudinal pulse occurs when a presetted vacuum threshold is reached and is less frequent than the pulse with a fixed rate in mixed longitudinal-lateral movement. For this reason, a reduced delivered energy has to be expected using IP. The key point was the tips that we used in our study. Twelve degree bent tip was not a good choice to show the real efficacy of torsional phacoemulsification. Tip selection is a very important factor in determining the energy delivery and the efficacy of the torsional emulsification; with 22°-bent tips, the efficiency of the torsional phaco increases.[20] Because the other group had a longitudinal component and the torsional US amplitude of this group was significantly lower than of the IP group, efficiency of the emulsification was not gradually affected by the type of tip. Probably less CDE can be achieved with IP torsional phacoemulsification by using more bent tips. Tip selection is very important for the efficiency of torsional phacoemulsification. Theoretically, there are 2 ways to enhance the cutting efficiency of the tip. First is the stroke length; the 22-degree bent 30-degree Kelman mini-flared tip cuts longer than the 12-degree bent 30-degree mini-flared Kelman tip. Second is the angulation or bevel; the higher the degree (45 degrees), the better cutting efficiency (Figure 1). To show the influence of the stroke length on the outcomes of the torsional phacoemulsification, we performed a study. IP upgraded torsional microcoaxial phacoemulsification surgeries were compared by 22-degree or 12-degree bent tips. The 22-degree bent tip provided more effective lens removal than the 12-degree bend tip with a lower UST and CDE regardless of nucleus grade (Table 1).[21] We have also conducted a study to analyze the cutting efficiencies of the 22-degree bent, 30- and 45-degree aperture angled tips. Theoretically, it is known that the 45-degree tip provides better "cutting", and it is believed that the 30-degree tip provides better "holding". Therefore, it would make some sense that the 45-degree tip would perform better in a more chop-dominant approach. On the other hand, a more tip-occlusive/less chopping technique could theoretically lead to greater efficiency with a 30-degree tip. Most of the surgeons get used to use 30-degree Kelman tips since the smaller holding surface of this tip, when compared to 45-degree tips, provides better control over the nucleus material. But with the chop technique and fluid-energy settings used in our study, no significant difference was observed between the groups for the amount of BSS used and the followability of the groups was

Table 1. Surgical outcomes of the 2.2-mm microcoaxial phacoemulsification using Ozil IP torsional mode with 22º or 12º bent tips (From the study: Helvacioglu F, Yeter C, Tunc Z, Sencan S. The outcomes of Ozil IP torsional microcoaxial phacoemulsification performed by 12 and 22 degree bent tips. J Cataract Refract Surg. 2013; 39:1219-25.)

Groups	UST	CDE	Longitudinal Us Amplitude	Torsional Us Amplitude	Mean Operation Time	Mean Volume of BSS
Group 1	60.50 sec. ±27.23 sec.	11.53±6.99	0.22±0.26	42.86±15.64	985 sec.±306 sec.	73.33 cc±28.58 cc
Group 2	84.5 sec. ±45.04 sec.	16.68±10.66	0.48±0.68	46.27±14.74	950 sec.±325 sec.	82.08 cc±26.21 cc
p-value	p=0.003	p=0.008	p=0.022	p=0.291	p=0.808	p=0.134

UST: Ultrasound time, CDE: Cumulative dissipated energy. BSS: Balanced salt solution.
Group 1: 2.2-mm microcoaxial phacoemulsification using Ozil IP torsional mode with 45º aperture angled tips
Group 2: 2.2-mm microcoaxial phacoemulsification using Ozil IP torsional mode with 30º aperture angled tips

Table 2. Surgical outcomes of the 2.2-mm microcoaxial phacoemulsification using Ozil IP torsional mode with 45º or 30º aperture angled tips (From the study: Helvacioglu F, Yeter C, Tunc Z, Sencan S, Uyar OM. The outcomes of Ozil IP torsional microcoaxial phacoemulsification performed by tips with 30 and 45 degree aperture angles. J Cataract Refract Surg. 2014 Epub doi:pii: S0886-3350(13)01520-4. 10.1016/j.jcrs.2013.07.051)

Groups	UST	CDE	Longitudinal Us Amplitude	Torsional Us Amplitude	Mean Operation Time	Mean Volume of BSS
Group 1	58.21 sec.±33.81 sec.	7.74±6.23	0.45±0.30	26.30±12.60	888,37 sec.±165.25 sec.	73.30 cc±19.87 cc
Group 2	63.83 sec.±23.42 sec.	12.36±6.75	0.23±0.26	44.65±14.38	919.02 sec.±277.92 sec.	74.30 cc±19.44 cc
p-value	p=0.389	p=0.002	p=0.001	p=0.001	p=0.545	p=0.821

UST: Ultrasound time, CDE: Cumulative dissipated energy. BSS: Balanced salt solution.
Group 1: 2.2-mm microcoaxial phacoemulsification using Ozil IP torsional mode with 45º aperture angled tips
Group 2: 2.2-mm microcoaxial phacoemulsification using Ozil IP torsional mode with 30º aperture angled tips

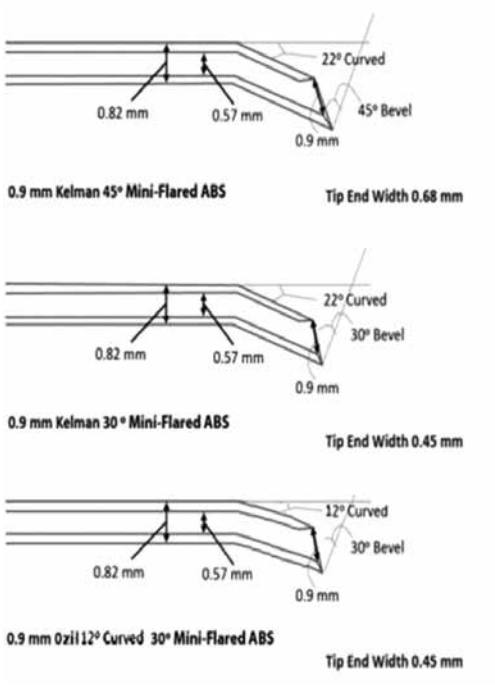

Figure 1. The anatomic details of the tips

similar. Although it could be influenced by many factors such as techniques, fluid-energy settings, and proximity of emulsification to the cornea during the operation, statistically significant less CDE and CCT changes were observed in the 45-degree group (Table 2). Since the stroke lengths of the tips are same, the efficacy would be directly related to the aperture angles of the tips. As a result, the operations were performed more efficiently with enhanced cutting effect of the 45-degree aperture angled tips.[22] These studies clearly demonstrated that the efficacy of the torsional phacoemulsification has positive correlation with both the aperture angles and neck angles of the tips. Our advice for the tip selection in torsional phacoemulsification is to use 22-degree bent tips, which clearly increases the stroke length. And for the angle at aperture of the tips, 45-degree tip would be a better choice regardless of cataract grade. Before getting used to performing surgeries with this tip, 30-degree aperture angled, 22-degree bent so called 'Kelman tip' could be efficiently used in cataracts up to grade 3.

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