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REVIEW ARTICLE

Bimanual microincisional cataract surgery technique and clinical outcome

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Abstract Bimanual microincisional cataract surgery has been introduced recently as a technique for cataract surgery and it is gaining interest of many cataract surgeons in the world. Over the last few years many changes were made in the phacoemulsification machines and the intraocular lenses design which allowed bimanual microincisional cataract surgery to be safer and more efficient. The purpose of this review is to introduce the technique of bimanual microincisional cataract surgery and to review all the prospective randomized studies comparing bimanual microincisional cataract surgery and standard phacoemulsification in term of safety and efficacy parameters.
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Contents

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1. Introduction

Cataract surgery is considered to be one of the most common surgical procedures performed worldwide. Dr. Kelman made major evolution in cataract surgery when he invented phacoemulsification in 1965 (Emery et al., 1978). Phacoemulsification machines have improved a lot over the last few years in term of providing efficient ultrasound and vacuum with good anterior chamber stability. Phacoemulsification continued to be done using coaxial technique in which sleeved hand piece is used to provide irrigation and aspiration through the same incision which is usually 2.75–3.2 mm in size and this has been called standard coaxial phacoemulsification.

Doing phacoemulsification through smaller wound was an area of interest for many surgeons. Shearing et al. (1985) was the first who described doing phacoemulsification through less than 2.0 mm incision which requires separation of irrigation and aspiration by using two different hand pieces (irrigating choppers and sleeveless phaco tip). This technique was called bimanual microincision phacoemulsification surgery. At that time, bimanual microincision cataract surgery did not gain surgeons interest since there was no available foldable intraocular lenses to be implanted through less than 2.0 mm incision which necessitates extending the main incision to about 3.0 mm in size in order to implant the intraocular lens.

Bimanual microincisional cataract surgery started to garner surgeons' interest by the year 2000 (Paul and Braga-Mele, 2005; Agarwal et al., 2001; Tsuneoka et al., 2001). The evolution in intraocular lenses made it possible to have an intraocular lens which can be implanted through less than 2.0 mm incision. For the last few years, the number of studies done to determine the safety and efficacy of bimanual microincision cataract surgery has increased (Agarwal et al., 2001; Tsuneoka et al., 2002; Soscia et al., 2002; Alio et al., 2005; Baykara et al., 2006; Mencucci et al., 2006; Kurz et al., 2006; Wilczynski et al., 2006; Assaf and El-Moatassem Kotb, 2007; Kahraman et al., 2007; Crema et al., 2007; Mathys et al., 2007; Praveen et al., 2008; Saeed et al., 2008). Advocates of bimanual microincisional cataract surgery claimed that the advantages of the new technique outweigh its disadvantages and it is a matter of time for the bimanual microincisional cataract surgery to replace the standard phacoemulsification. The advocates of bimanual microincisional cataract surgery claim the following advantages:

(1) Smaller incision cause less surgically induced astigmatism, better postoperative corneal optical quality, easier capsulorrhexis and hydrodissection, and may reduce the risk of endophthalmitis.
(2) The separation of irrigation and aspiration increase the followability of nuclear fragments.
(3) The flexibility of the two incisions allows the surgeon to have different angles to approach the nuclear fragments.
(4) The small size of the instruments allows better intraocular view.
(5) The separate irrigation steam may be used to protect the posterior capsule.

The disadvantages of bimanual microincisional cataract surgery include:

(1) It has learning curve.
(2) The limited irrigation cause anterior chamber instability.
(3) The lack of sleeve and tight wound may predispose to wound burn.

Till now we do not have clear definition for microincisional cataract surgery. Most of the studies defined microincisional cataract surgery as cataract surgery performed through a <2-mm incision. Alio (Agarwal, A. Microphaconit – Cataract surgery with a 0.7 mm Tip, IOAW Journal of Ophthalmology, 2007) was the first who used MICS as an abbreviation for microincisional cataract surgery. It will be appropriate to use B-MICS for bimanual microincisional cataract surgery.

2. B-MICS technique

2.1. Corneal incision

In B-MICS, we need two clear corneal incision of at least 1.0–1.2 mm width to accommodate the phaco hand piece and the irrigating instrument. Tight incision can lead to tension on the wound by the instruments with less fluid flow around the sleeveless phaco hand piece and may predispose to wound burn. Making the incision slightly larger about 1.4 mm will allow the fluid to leak through the wound with adequate cooling of the phaco hand piece but may predispose to anterior chamber instability (Weikert, 2006). The two incisions usually 90–100° apart and can be placed in the superonasal and superotemporal quadrants or in the inferotemporal and superotemporal quadrants.

2.2. Capsulorrhexis

Advocates of B-MICS claim that capsulorrhexis is easier in B-MICS since smaller incision theoretically prevent loss of viscoelastic and therefore provide a more stable anterior chamber (Paul and Braga-Mele, 2005; Soscia et al., 2002). Capsulorrhexis can be performed through one of the incision using bent needle cystotome or micro-capsulorrhexis forceps (Weikert, 2006). Hydrodissection and hydrodelineation are performed through the incisions.

2.3. Phacoemulsification

Most of the currently available phaco units can be used to perform B-MICS (Paul and Braga-Mele, 2005; Hoffman et al., 2005). Using sleeveless hand piece made it possible to introduce phaco hand piece through a <1.5 mm incision. Wound burn was a major issue in B-MICS, since the sleeveless phaco hand piece doesn't have irrigation fluid to cool it and the tip is in direct contact with the wound. To avoid wound burn, the phacoemulsification parameters in B-MICS are different than standard phaco since we need to decrease the raise in wound temperature while marinating adequate energy. Ultrasound energy setting are usually lower than with standard phaco and with use of pulse mode, burst mode to produce less energy with more efficiency (Weikert, 2006). In B-MICS the irrigating fluid comes through a 19 gauge or 20 gauge irrigating chopper or manipulator which has single or two irrigating holes located frontally, laterally, or inferiorly based on surgeon preference. The irrigating fluid going inside the eye is less than standard phaco which predispose to anterior chamber instability. To overcome this problem, vacuum and aspiration flow rate in B-MICS are usually lower than standard phaco and irrigating fluid can be increased by raising the bottle height and/or pressurize the infusion (Paul and Braga-Mele, 2005). Advocates of B-MICS claim that separating irrigation and aspiration increase the followability of nuclear fragments and make fragment aspiration easier than standard phaco where irrigation from the phaco hand piece tend to push the fragment away from the phaco tip (Paul and Braga-Mele, 2005; Soscia et al., 2002).

Phacoemulsification can be carried out using different techniques such as chop (horizontal or vertical), flip, divide and conquer, or using prechopper to crack the nucleus (Alio et al., 2005).

2.4. Irrigation and aspiration

Bimanual irrigation and aspiration instruments are used and both instruments can be switched to reach subincisional cortex (Paul and Braga-Mele, 2005).

2.5. Intraocular lens implantation

The evolution in intraocular lenses design made microincisional cataract surgery become true. Currently there are eight different single piece hydrophilic acrylic MICS IOLs available for implantation through sub 2.0 mm incision (Alio et al., 2006). These lenses include:

(1) Acri.Smart IOLs (Acri-Tec, Zeiss Meditec A, Jena, Germany). The Acri.Smart family includes intraocular lenses with monofocal, bifocal and bitoric optics in spherical and aspherical design.
(2) ThinOptX Ultrachoice 1.0 IOL (ThinOptX Inc., Abrindon, Virginia, USA).
(3) AcriFlex MICS 46CSE IOL (Acrimed GmbH, Berlin, Germany).
(4) SuperFlex and C-flex IOLs (Rayacryl Rayner Intraocular Lenses Ltd., UK).
(5) IOLtech microincision lens (IOLtech S.A., Zeiss Meditec A, Jena, Germany).
(6) TetraFlex Kh-3500 microincision lens (Lenstec Inc., Florida, USA).
(7) AKREOS MI 60 (Bausch Lomb, Rochester, NewYork, USA).

All the current MICS IOL model require insertion through corneal wound >1.5 mm, but $\leqslant 2.0$ mm using wound-assisted techniques (Weikert, 2006).

3. B-MICS clinical results

3.1. Visual outcome

Postoperative uncorrected visual acuity (UCVA) was better in B-MICS than standard phaco but not statistically different (Saeed et al., 2008). Alio et al. (2005) found that postoperative UCVA in B-MICS group was better at day 1, and 1 month but not at 3 months and the differences was not statistically significant.

Postoperative best corrected visual acuity (BCVA) was found to be statistically better with B-MICS than standard phaco (Kurz et al., 2006). Other studies did not find any statistical differences between the two techniques (Alio et al., 2005; Kurz et al., 2006; Wilczynski et al., 2006; Crema et al., 2007; Denoyer et al., 2008.

3.2. Refractive outcome

One of the most important advantages of small corneal incision in B-MICS is the reduction in surgically induced astigmatism (SIA). Alio et al. (2005) measured the SIA using corneal topography which was calculated by vectorial analysis and showed that in B-MICS group a mean of vectorial astigmatic change of 0.36 ± 0.230 D was induced, compared with 1.2 ± 0.74 D in the standard group ($P < 0.001$). The incision in both group was placed on the positive corneal meridian. Kurz et al. (2006) measured the median changes in corneal astigmatism which was −0.15 D in the B-MICS group, versus −0.31 D in the standard group. The difference was not statistically significant ($P = 0.08$). The incision in B-MICS group was placed at 11 o'clock while in the standard group, it was at 12 o'clock. Yao et al. (2006) measured the change in simulated keratometry ($\Delta \mathrm{Sim}K$) values, which was obtained from corneal wavefront aberration map. The mean postoperative $\Delta \mathrm{Sim}K$ value was 0.78 ± 0.38 D for B-MICS group and 1.29 ± 0.68 D for the standard group. The difference between the two groups was statistically significant ($P = 0.001$). The incisions in both groups were placed superiorly. Denoyer et al. (2008) measured the vectorial magnitudes of the surgically induced refractive astigmatism and corneal astigmatism. The difference for both magnitudes was not statistically significant between both groups.

Table 1 Summary of studies comparing efficacy parameters in B (B-MICS) and S (standard phaco).

Study	No. of eyes	F/U	UCVA	BCVA	SIA	HOA	EPT	APP	PT	ST
Kurz et al. (2006)	70	8 weeks	–	Better in B $P = 0.015$	Less in B Not significant	–	$B < S$ $P = 0.013$	Less in B Not significant	–	–
Alio et al. (2005)	100	3 months	Not significant	Not significant	Less in B $P < 0.001$	–	Less in B $P = 0.001$	Less in B $P = 0.001$	Not significant	Not significant
Yao et al. (2006)	60	1 month	–	–	Less in B $P < 0.001$	Not significant	–	–	–	–
Crema et al. (2007)	60	1 year	–	Not significant	–	–	–	Not significant	Less in S $P < 0.001$	
Wilczynski et al. (2006)	40	10 days	–	Not significant	–	–	–	Less in S Not significant	Less in B Not significant	–
Denoyer et al. (2008)	60	3 months	–	Not significant	Not significant	Lower in B $P < 0.001$	–	–	–	–
Kahraman et al. (2007)	66	3 months	–	–	–	–	–	–	Less in B $P = 0.001$	Less in S $P = 0.004$
Mencucci et al. (2006)	80	3 months	–	–	–	–	Less in S Not significant	Less in S Not significant	Less in S Not significant	Not significant
Saeed et al. (2008)	100	2 weeks	Better in B Not significant	–	–	–	–	Less in S $P < 0.001$	Less in B Non significant	–

F/U, follow up; UCVA, uncorrected visual acuity; BCVA, best corrected visual acuity; SIA, surgically induced astigmatism; HOA, corneal higher order aberration; EPT, effective phaco time; APP, average percentage phaco power; PT, phaco time; ST, total surgery time; B, B-MICS; S, standard phaco.

Table 2 Summary of studies comparing safety parameters in B (B-MICS) and S (standard phaco).

Study	ECL	Pachy	Coeff. of variation in cell size	Hexagonality	Laser flare	Complication	BSS
Kurz et al. (2006)	Not significant	–	–	–	Not significant	No	–
Alio et al. (2005)	Not significant	Not significant	–	–	Not significant	No	Not significant
Crema et al. (2007)	More in B $P < 0.01$	–	–	–	–	No	–
Wilczynski et al. (2006)	More in B Not significant	–	–	–	–	–	–
Kahraman et al. (2007)	More in B Not significant	Not significant	Not significant	Not significant	Not significant	–	Not significant
Mencucci et al. (2006)	Not significant	Not significant	Not significant	Not significant	–	–	Less in B Not significant

ECL, endothelial cell loss; Pachy, corneal pachymetry; BSS, total balanced salt solution.

3.3. Corneal aberration

The optical quality of the cornea is essential to good vision (Elkady et al., 2008). Since B-MICS has less surgically induced astigmatism in comparison with standard phacoemulsification which might be associated with better optical quality.

Denoyer et al. (2008) found that the 3 months postoperative root mean square of 3rd–6th order corneal aberrations was lower in B-MICS eyes than in standard eyes (0.705 ± 0.285 µm versus 0.956 ± 0.236 µm, respectively) which was significantly different ($P < 0.001$) and the root mean square for the 3rd–6th order ocular aberration was lower in B-MICS eyes (0.308 ± 0.122 µm versus 0.488 ± 0.172 µm) with significant difference ($P = 0.002$). The individual higher order aberration 3rd-order trefoil and trefoil-like aberration were statistically lower in the B-MICS.

Yao et al. (2006) reported mean postoperative total corneal high order aberration value were 2.04 ± 1.23 µm for B-MICS group and 1.80 ± 0.87 µm for standard group. The value was better with standard phaco but the difference was not significant ($P = 0.408$). Analysis of some individual higher order aberrations such as spherical aberrations, coma aberrations, total trefoil and total quadrafoil showed no significant difference between groups. Elkady et al. (2008) compared the preoperative and postoperative corneal aberration after B-MICS. The RMS value of the total corneal aberrations, spherical aberration and coma decreased slightly after B-MICS at 1 month and 3 months postoperatively, but the differences were not statistically significant.

3.4. Phacoemulsification surgical parameters and surgery time

In B-MICS, phacoemulsification parameters were adjusted to overcome the possibility of wound burn and anterior chamber instability. The need for decreasing the power and vacuum was thought to be associated with increase in the effective phaco time, average percentage power, phacoemulsification time and surgery time.

Studies have confirmed that B-MICS offer statistically significant decrease in effective phacoemulsification time when compared with standard phacoemulsification (Alio et al., 2005; Kurz et al., 2006). Alio et al. (2005) found statistically significant decrease in the average percentage power used in B-MICS group ($P = 0.001$), while Saeed et al. (2008) found the average percentage power less with standard phaco ($P < 0.001$). Other studies (Mencucci et al., 2006; Kurz et al., 2006; Wilczynski et al., 2006; Crema et al., 2007) found no statistical differences between the two techniques.

Phacoemulsification time was not consistent among studies. Kahraman et al. (2007) found B-MICS offer statistically significant decrease ($P = 0.001$), while Crema et al. (2007) found that standard phacoemulsification offer statistically significant decrease in phacoemulsification time ($P < 0.001$). Other studies (Alio et al., 2005; Mencucci et al., 2006; Wilczynski et al., 2006) found no differences between the two techniques.

Total surgery time was similar in both techniques (Alio et al., 2005; Mencucci et al., 2006). Kahraman et al. (2007) found that standard technique offer statistically significant shorter surgery time ($P = 0.004$).

3.5. Postoperative endothelial cells

Endothelial cells changes are considered important parameters of surgical trauma and are essential for estimating the safety of surgical technique (Mencucci et al., 2006). Trauma to the endothelium leads to decrease endothelial cell density, increase coefficient of variation of cell area (variation in cell size), decrease percentage of hexagonal cells, and increase corneal thickness.

Crema et al. (2007) found that endothelial cell loss was higher in B-MICS after 1 year follow up with $P < 0.01$. Other studies (Alio et al., 2005; Mencucci et al., 2006; Wilczynski et al., 2006; Kahraman et al., 2007; Kurz et al., 2007) did not find any statistically significant differences in the endothelial cell loss between the B-MICS and standard technique with 3 months follow up only.

The coefficient of variation in cell size and hexagonality were similar in both techniques (Mencucci et al., 2006; Kahraman et al., 2007). Corneal thickness found to be similar in both groups at 3 months follow up (Alio et al., 2005; Mencucci et al., 2006; Kahraman et al., 2007).

3.6. Total balanced salt solution volume

The amount of fluid circulating in the anterior chamber is an important safety parameter since more fluid circulating in the anterior chamber may lead to corneal endothelial damage (Mencucci et al., 2006). Studies found no differences in the total balanced salt solution volume used with B-MICS and standard phaco (Alio et al., 2005; Mencucci et al., 2006; Kahraman et al., 2007).

3.7. Postoperative inflammation

Postoperative inflammation can be used as an indicator for more intraoperative phacoemulsification power and longer surgery time. Using laser flare photometry, no differences in the postoperative inflammation found with B-MICS and standard phaco (Alio et al., 2005; Kurz et al., 2006; Kahraman et al., 2007).

3.8. Intraoperative and postoperative complication

Intraoperative and postoperative complications are important parameters to measure the safety of new surgical technique. Three studies (Alio et al., 2005; Kurz et al., 2006; Crema et al., 2007) looked at intraoperative and postoperative complications and reported that corneal burn, wound leak, posterior capsule rupture, zonular dehiscence, and endophthalmitis were not seen in any of the patients operated with B-MICS or standard technique. B-MICS is thought to be safer than standard phaco with a reduce risk of postoperative endophthalmitis. Chee and Bacsal (2005) reported a case of streptococcal endophthalmitis after uneventful B-MICS.

3.9. Wound architecture and integrity

Alteration in corneal wound architecture with B-MICS continued to be a concern. Because of the tight wound, the instrument will be in contact with wound edge and excessive manipulation can induce more wound stress and alteration of wound morphology. B-MICS is done with sleeveless phacoemulsification tip which means no irrigation coming with the tip to cool it and eventually it may increase the risk of corneal burn and the loss of morphology. Praveen et al. (2008) assessed the ingress of trypan blue intraoperatively group of patients who had B-MICS, C-MICS, and standard technique and he found that the ingress of trypan blue was statistically significantly higher in B-MICS than standard at the end of surgery and following cortical removal.

4. Conclusion

B-MICS appears to have promising future and may replace the standard phaco technique in the near future. The modification made by the companies to make phaco machines suitable for B-MICS as well as the major evolution in the design of MICS IOLs play a major role in increasing the popularity of B-MICS among cataract surgeons. Clinical studies have been positive emphasizing the safety and efficacy of B-MICS. Studies have confirmed that B-MICS is superior to standard phaco in efficacy parameters such as BCVA, SIA, higher order aberration, effective phacoemulsification time, and average percentage power (Table 1). Safety parameters (Table 2) in B-MICS are similar to standard technique with the exception of wound integrity, although clinical studies did not find differences in wound leak between B-MICS and standard phaco. The main drawback of B-MICS is the learning curve which makes many surgeons hesitant to change, since they are comfortable and satisfied with standard phaco. The other challenge for B-MICS to be the standard technique for cataract surgery is the newly introduced coaxial microincisional cataract surgery (C-MICS) (Dosso et al., 2008). Currently, C-MICS is doable through 1.8 mm incision with no learning curve. Future studies have to confirm either B-MICS or C-MICS is safer and more efficient.

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