

Preferred practice pattern and observed outcome of deep anterior lamellar keratoplasty – A survey of Indian corneal surgeons

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Purpose: This study aimed to assess the preferred surgical technique and outcome of deep anterior lamellar keratoplasty (DALK) among corneal surgeons in India. **Methods:** An online questionnaire-based cross-sectional survey was conducted among members of the Cornea Society of India (CSI) with experience of performing >10 DALK procedure. The responses pertaining to their surgical experience, preferred technique, complications, and outcome of DALK were collected and analyzed. **Results:** A total of 156 responses were received. In total, 35.9% of participants reported annual keratoplasty of >50, and DALK constituted >25% surgeries for 25% of participants. Ectatic corneal disorder was reported as the most common indication for DALK by 71.6% of the respondents. Big-bubble (BB) DALK (W_A -1.82) was the most preferred technique, along with suction trephine (50%) for partial trephination and bottom port cannula (45.5%) for BB formation. On statistical analysis, no difference was observed in the surgeon reported success rate of BB formation with or without anterior lamellar keratectomy (ALK) (χ^2 (1,156) = 3.1498, P = 0.08) or paracentesis (χ^2 (1,156) = 0.2737, P = 0.60) before stromal air injection, and method of stromal air injection (χ^2 (1,156) = 4.7325, P = 0.09). Conversion to penetrating keratoplasty was reported by 16% of participants in >25% cases, while 66.7% reported in <10% cases. Cataract and double anterior chamber were the most common complications. 50% of participants suggested that >20 procedures are required to overcome the learning curve. **Conclusion:** BB DALK is the most commonly practiced DALK technique, and its success is independent of ALK and paracentesis being performed prior to air injection and method of air injection (cannula/needle).

Key words: Big bubble DALK, corneal surgeons, DALK, deep anterior lamellar keratoplasty, keratoplasty

Constant evolution in the surgical technique of anterior lamellar keratoplasty has been observed over the last 150 years.^[1-3] The initial phase witnessed poor acceptance of anterior lamellar keratoplasty due to the associated poor visual outcome and difficult surgical procedure.^[4,5] Recently, with the availability of various surgical instruments and modifications in the surgical technique, the outcome has dramatically improved, resulting in a resurgence of interest among corneal surgeons world-over in this treatment modality.^[6-9]

Deep anterior lamellar keratoplasty (DALK) is the most commonly performed anterior lamellar keratoplasty. It involves host corneal dissection with the baring of the Descemet membrane (DM)/pre-Descemet layer (PDL) before suturing of donor corneal graft that is devoid of Descemet-endothelium complex.^[2,6-9] Various techniques for corneal dissection have been described, including air-assisted dissection, fluid assisted dissection, viscoelastic assisted dissection, and double bubble technique.^[6-10] Preservation of host corneal endothelium reduces the risk of graft rejection and therefore improves the graft survival rate.^[11-13] Also, this technique is devoid of complications of an open globe surgery, as seen in penetrating

keratoplasty (PKP).^[14] However, a steep learning curve, variable surgical techniques, and associated intra-operative complications are the major factors limiting its practice to selected corneal surgeons.^[2,4,6-9]

Various corneal surgeons have reported their preferred surgical technique of DALK and its long-term outcome; however, limited literature is available on the corneal surgeons' preferred surgical practice pattern. In this survey, we aim to focus on the preferred surgical technique for DALK among corneal surgeons in India and its impact on the surgical outcome.

Methods

A questionnaire-based cross-sectional study was conducted among members of the Cornea Society of India after approval from the institutional review board. The study adhered to the tenets of the declaration of Helsinki.

A 29-question survey was developed using the SurveyMonkey website (Supplementary Content 1) after

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validation by four experts in the field of keratoplasty. The questions pertained to the surgeon's experience in keratoplasty, preferred surgical technique of DALK, success rate of big bubble DALK (BB DALK), and observed intra-operative and post-operative complications. Various questions were directed towards specific surgical steps of BB DALK and the success rate of forming a big bubble (BB) that could help establish a correlation between a particular technique and its success in forming big-bubble, which is one of the most crucial steps in the success of this surgery. The questionnaire was pilot tested on 20 participants who had proficiency in English language. The questionnaire was revised based on the findings of the pilot study.

A link to the validated questionnaire was emailed to all the cor-net group members, which is the official interactive forum for members of the Cornea Society of India. The email requested that the survey participants should be corneal surgeons based in India with experience of performing ≥ 10 DALK. (Supplementary Content 2) The unique response link allowed completing the survey only once. The responses were collected, and data were exported to an excel sheet. Statistical analysis was performed using SPSS software.

Results

The questionnaire was completed by 156 members of the Cornea Society of India. The participants included ophthalmologists trained in corneal transplantation and practicing in varied places, including the public and private sector, solo and group practice, as well as rural and urban areas.

Surgical experience

The annual optical keratoplasty rate of >25 was reported by 64.8%, >50 by 35.9% and, >100 by 17.3% of the respondents. The pattern of keratoplasty performed by DALK surgeons revealed that penetrating keratoplasty (W_A -2.7) (weighted average = W_A) was the most common corneal transplant procedure performed by the respondents, with 21.8% reporting that it constituted $>50\%$ of the keratoplasties. This was followed by DSEK/DSAEK (W_A - 2.1) and DALK (W_A - 2.0). [Fig. 1] Approximately 25% of the respondents reported that DALK constituted $>25\%$ of their annual keratoplasty procedures. The most common indication for performing DALK as reported by the respondents was Ectatic corneal disorder (71.6%) followed by corneal scar (18.2%), corneal dystrophy (4.6%), infections, (2.8%), and ocular surface reconstruction (4.9%) [Fig. 2].

Surgical technique of DALK

On enquiring the participants about the type of anesthesia used for performing DALK, local anesthesia (W_A -4.0) was preferred over general anesthesia (W_A -3.5). The surgical technique preferred by most of the respondents was BB DALK (W_A -1.82), followed by manual (W_A -1.7), and viscoelastic assisted DALK (W_A -1.1) [Fig. 3]. BB DALK was the first choice for 59.5% of the respondents (n-88/148). On enquiring about the preferred corneal trephine for DALK, 50% of respondents (n-78/156) reported the use of suction trephine followed by hand-held metal trephine (34.6%, n-54/156) and hand-held guarded depth trephine (12.8%, n-20/156). Only one participant (0.006%, n-1/156) reported the use of a femtosecond laser for host corneal trephination. Over 88% of the participants reported the use of trephine size between

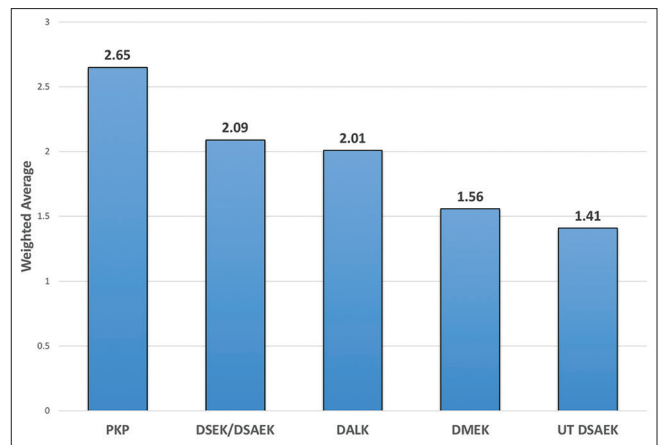


Figure 1: Weighted average of various keratoplasties among participant corneal surgeons

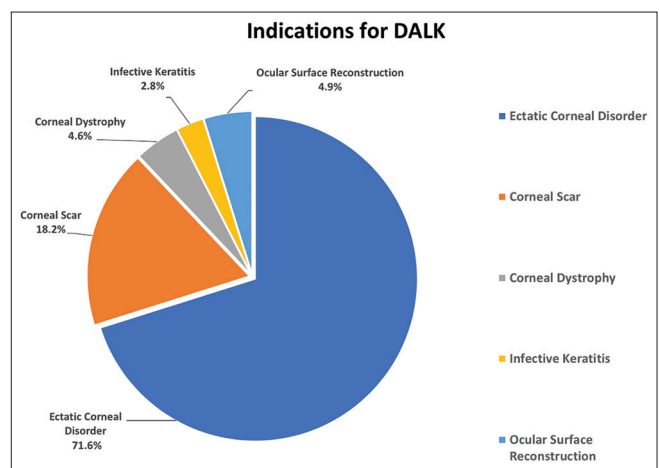


Figure 2: The most common reported indication for DALK among participant corneal surgeons

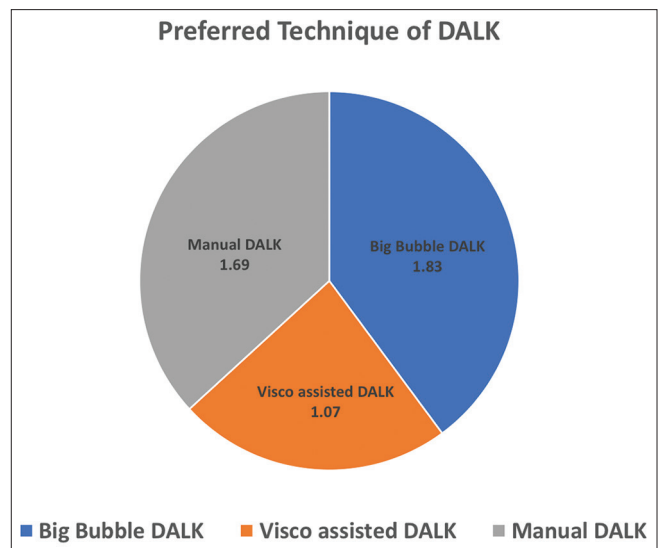


Figure 3: Preferred technique of DALK among participant corneal surgeons

7.5 mm to 8.5 mm for host corneal trephination. Anterior lamellar keratectomy (ALK) was performed by $>85\%$ of the

surgeons, while paracentesis was performed by only 56.4% of the surgeons before air injection in BB DALK. On enquiring about the preferred instrument for air injection in DALK, the use of bottom port air injection cannula was reported by 45.5% of the participant surgeons, followed by 26/27 gauge needle (27.6%) and 30 gauge needle (26.9%). The successful formation of BB in >50% cases was reported by 46.2% of the participants, while 10.9% of participants reported <10% success rate. On enquiring about the type of BB achieved, respondents reported that Type 1 BB (W_A -3.5) was most commonly observed, followed by Type 2 (W_A -1.99) and mixed/Type 3 (W_A -1.5). The chances of successful BB formation in >50% cases was highest with 30 gauge needle (54.8%) followed by bottom port air injection cannula (49.3%) and 26/27 gauge needle (32.6%).

In cases of a BB formation that does not reach the trephination edge, manual dissection and trimming of the stromal tissue in the periphery (W_A -2.9) was the most preferred technique for proceeding.

The result of questions related to donor cornea preparation revealed that 95.5% of surgeons strip the donor corneal Descemet endothelium complex; however, 4.5% of the surgeons do not perform this step. Also, donor cornea oversizing by 0.25-0.5 mm is performed by most of the surgeons (W_A -4.6), while very few surgeons reported under-sizing the graft by 0.25-0.5 mm (W_A -2.42; n-19/155).

The interrupted suturing technique was the most preferred technique of graft suturing (W_A -5.5), followed by combined interrupted and continuous (W_A -3.7). Intra-operative use of keratoscope for suture adjustment during DALK was reported by 50% of the participant surgeons.

Intra-operative & post-operative complications

Spontaneous rupture of BB was observed by 56.9% (n-87/153) of the surgeons; however, it was noted in <10% of the surgeries by 83.9% (n-73/87) of these surgeons. Intra-operative corneal perforation was encountered by 88.5% (n-138/156) of the participant surgeons while attempting to manage the residual stromal tissue in the periphery. However, this complication was observed in <10% cases by 69.5% (n-96/138) of these surgeons. Most of the surgeons (88.3%) reported the use of air for tamponade in cases that developed perforation during DALK, and only 11.7% of participant surgeons reported the use of iso-expansile gases (SF6/C3F8). Pharmacological pupillary dilation and inferior peripheral iridotomy (PI) were the preferred techniques to avoid pupillary block in these cases. Only 17.6% of the participant surgeons reported burping out of air/gas after 1-2 hours of surgery. Almost 50% of surgeons reported encountering Urrets Zavalia (UZ) syndrome in DALK. There was no difference in the occurrence of UZ syndrome with air or gas tamponade (p-0.55) and inferior peripheral iridotomy, mydriasis, or air burping (p-0.21) in cases that required tamponade.

Conversion to PKP was observed by 16% of the participant surgeons in >25% of the cases, 17.3% of the participant surgeons in 11-25% of the cases, and 66.7% of the participant surgeons in <10% of the cases. The common post-operative complications observed in patients who underwent DALK included cataract, double anterior chamber, non-healing epithelial defect, and graft rejection. Visual outcome following DALK was reported

to be similar to PKP by 44.5% of the participant surgeons, while 35.8% reported outcomes superior to PKP, and 20% reported outcomes inferior to PKP.

Over 50% of participant surgeons believed that up to 20 cases of DALK are sufficient to overcome the learning curve; however, 43.6% of participants were of the view that >20 cases are required for overcoming the learning curve.

Modifications in surgical technique & Correlation with big bubble formation

BB success rate of >50% in surgeons who performed - ALK before air injection compared to those who didn't was noted by 43.3% and 63.6% of participants, respectively. Similarly, the BB success rate of >50% in surgeons who performed paracentesis before air injection compared to those who did not was noted in 44.3% and 48.5%, respectively. The success rate of >50% for BB formation was noted by 43.5% in participants who used a needle for stromal air injection compared to 49.3% in participants who used the bottom port cannula for stromal air injection.

On evaluating the combined impact of the combination of ALK, paracentesis, and method of air injection on the success of BB formation (>50%), the highest success rate (83.3%) of BB formation was observed in surgeons' who reported use of cannula for air injection and did not perform prior ALK or paracentesis [Tables 1 and 2]. However, the number of surgeons in this category is low (n-5) to come to a definite conclusion. Also, the BB formation success rate was high (70%; n-7/10) when neither paracentesis nor ALK was performed (n-10) with any method used for stromal air injection.

On statistical analysis, no difference was observed in the surgeon reported success rate of BB formation (>50%) with or without ALK (X^2 (1,156) = 3.1498, P = 0.08) or paracentesis (X^2 (1,156) = 0.2737, P = 0.60) before stromal air injection in BB DALK. (Table 1) Similarly, the technique of air injection (26G needle/30G needle/Bottom port of cannula) did not affect the success rate of BB formation (>50%) (X^2 (1,156) = 4.7325, P = 0.09).

Table 1: Big Bubble success rate with variation in surgical technique

| | BB success rate >50% n=72 (% , n) | BB success rate >75% n=24 (%) |
|-------------------------------------|--------------------------------------|----------------------------------|
| Technique of air injection | | |
| Cannula | 49.3% (35) | 19.72% (14) |
| 26G/27G Needle | 32.56% (14) | 4.65% (2) |
| 30G Needle | 54.76% (23) | 19.05% (8) |
| P^* | 0.0938 | 0.0721 |
| Anterior Lamellar Keratectomy | | |
| Prior to air injection | | |
| ALK | 43.28% (58) | 13.43% (18) |
| No ALK | 63.64% (14) | 27.27% (6) |
| P^* | 0.0793 | 0.0954 |
| Paracentesis prior to air injection | | |
| Paracentesis | 44.32% (39) | 11.36 (10) |
| No Paracentesis | 48.53% (33) | 20.59 (14) |
| P^* | 0.6008 | 0.1130 |

BB - Big bubble; ALK - Anterior lamellar keratectomy. *Chi-square test

Table 2: Impact of Anterior lamellar keratectomy, paracentesis and air injection method on success rate of big-bubble (BB) formation

| | Paracentesis % (n) | No paracentesis % (n) |
|--|--------------------|-----------------------|
| Big Bubble success rate in air injection with Cannula (n=71) | | |
| ALK | 41.67% (10/24) | 47.06% (16/34) |
| No ALK | 57.14% (4/7) | 83.33% (5/6) |
| Big Bubble success rate in air injection with Needle (n=85) | | |
| ALK | 42.31% (22/52) | 41.67% (10/24) |
| No ALK | 60% (3/5) | 50% (2/4) |

*>50% times BB formation was considered as success rate of BB.

ALK - anterior lamellar keratectomy

Discussion

Anterior lamellar keratoplasty as an alternative to PKP has been favored by researchers for clinical conditions that involve the cornea but have a healthy endothelium.^[15,16] Chen *et al.*, in a meta-analysis study comparing DALK with PKP for keratoconus, reported better BCVA, a lower rate of graft rejection, cataract, and rise in intra-ocular pressure, and better endothelial cell count in cases that underwent DALK.^[11] However, anterior lamellar keratoplasty still constitutes a low proportion of the overall performed keratoplasties.

Park *et al.* in a ten-year review of Eye bank association of America (EBAA), reported that the proportion of anterior lamellar keratoplasty showed a significant rise from 1.4% in 2005 to 2% in 2014.^[4] However, it was the fourth most commonly performed keratoplasty after PKP, DSAEK, and DMEK.^[4] On the contrary, a 27-year review from the Iran's Central eye bank reported that anterior lamellar keratoplasty was the second most commonly performed keratoplasty (14.2%) after PK (70%).^[17] The current survey results reported that DALK was the third most commonly performed surgery after PKP and DSAEK/DSEK in India. The high surgical rate of DALK could be because the survey included surgeons who had experience of performing > 10 DALK procedures and therefore were expected to be practicing this surgical procedure.

Anwar and Teichman *et al.* described the technique of big bubble DALK in 2002.^[7] Various studies had been reported henceforth comparing its outcome with other techniques of DALK.^[16,18-20] Inferior visual outcome is reported in cases with residual posterior stromal tissue, especially in manual DALK.^[16,18-20] Hence, BB DALK has become the preferred technique for DALK among experienced corneal surgeons. In the current study as well, BB DALK was the most preferred technique, followed by manual and viscoelastic assisted DALK.

The original technique of BB-DALK was described with the use of a 27G/30G needle for stromal air injection.^[7] Following this, various modifications have been tried, of which cannula with bottom port has emerged as one of the most widely used methods. Sarnicola *et al.*, reported a higher success rate of BB formation (82% vs. 61%) and dDALK (94% vs. 78%) with cannula compared to a needle.^[21] However, all surgeries

were performed by the same surgeon and did not take into consideration the inter-surgeon variation in the expertise of DALK. In the current survey, no difference was observed in the success rate of BB formation between the three techniques of stromal air injection (26G needle, 27/30G needle & cannula with bottom port). The difference from existing literature may be because the current survey is based on responses obtained from multiple surgeons with variable practice patterns and surgical experience. Our results suggest that the surgeon's expertise and comfort in the technique of stromal air injection is probably a more important predictor of BB success than the instrument used for air injection itself.

Few surgeons perform debulking ALK and paracentesis before air injection in BB DALK. It is presumed that both these maneuvers increase the success of BB formation. However, in the current study, no difference was observed in the success rate of BB formation with these additional maneuvers.

Literature review suggests that the rate of corneal perforation in DALK varies from 4% to 39.2%, and the conversion rate to PK is 2.96%. In the current study, the conversion rate to PK was higher than that reported in the literature. Approximately two-third of surgeons reported a conversion rate of >5%. This difference can be because the current study is based on responses obtained from multiple surgeons with varying surgical expertise, while most of the studies conducted in the past are based on outcomes of a single surgeon usually with enormous surgical experience of lamellar keratoplasty. Gadhvi *et al.* in a multi-surgeon study, reported a high perforation rate of 45% and conversion to PK in 24.1% of the cases.^[22] Similarly, Coster *et al.* reported conversion to PK in 14% based on the Australian graft registry data.^[23]

In cases with corneal perforation wherein DALK is attempted, tamponade of the perforation site by intracameral air or gas (14% C3F8 or 20% SF6) acts as a rescue measure. However, there is an associated risk of pupillary block glaucoma, UZ syndrome, and cataract.^[10,24] In accordance with the existing literature, air was the most common agent used for tamponade of intra-operative Descemet perforation in this study.^[25,26] Also, majority of surgeons in the current study reported either performing a PI or inducing pharmacological mydriasis to avoid post-operative complications. However, approximately half of the participants reported encountering UZ syndrome in cases that required a tamponade agent. On statistical analysis, there was no difference in the occurrence of UZ syndrome with air or gas tamponade (p=0.55) and preventive measures that included inferior PI, mydriasis, or air burping (p=0.21).

The common early post-operative complications of DALK include double anterior chamber (AC), UZ syndrome, and persistent epithelial defect (PED), while cataract, interface vascularization, stromal rejection, and post-traumatic graft dehiscence are the late complications. Gadhvi *et al.* in a multi-surgeon study on DALK, reported graft rejection (19%) as the most common complication followed by raised intraocular pressure and double anterior chamber.^[22] However, in the current study, double anterior chamber and cataract were the most common reported complication.

Variable results have been reported in the literature on the visual outcome of DALK when compared to PK. Recently a

metanalysis, as well as a systematic review study, reported better visual outcomes with PKP when compared to DALK.^[11,12] On the contrary, a report from the American Academy of Ophthalmology reported similar visual outcomes between DALK and PKP.^[15] A similar result was observed in the current study. Comparable or better visual outcome was reported with DALK when compared to PKP by 80% of the participants. The obtained difference in various studies can be due to differences in the surgical caseload of DALK in different countries that can impact the surgeons' overall surgical expertise and training during fellowship programs. As DALK is known to have a steep learning curve, this factor can influence the surgical outcome. Also, donor orientation and suture tension may be more optimal in DALK considering that it is a closed chamber surgery, resulting in reduced post-operative astigmatism and better visual outcome.

DALK, among all other keratoplasty techniques, has a steep learning curve with a high complication rate during the initial surgeries. A literature review suggests a declining trend of complications with an increasing number of DALK cases performed.^[27] In the current study, the majority of the participants were of the opinion that >10 cases are required to overcome the learning curve.

The major limitations of the study include recall bias and self-selection bias, as seen with any other questionnaire-based survey. Also, we requested surgeons with experience of performing >10 DALK to participate in this survey, but there is no means of verifying this parameter. However, the major advantage is that it reports the preferred surgical techniques and outcome of DALK from a large section of corneal surgeons compared to most other studies in the literature, which are based on single surgeon results who are often dedicated DALK surgeons. This is unlike the real-life scenario wherein corneal surgeons perform both full-thickness and lamellar (anterior/posterior) keratoplasty and thus may have different preferences of surgical technique and outcome when compared to dedicated DALK surgeons.

Conclusion

To conclude, the results of the study suggest that BB DALK is the most commonly performed technique of DALK, with a needle being the most common instrument used for stromal air injection. The success rate of BB formation was noted to be independent of the three considerably important factors – ALK and paracentesis prior to stromal air injection and method of stromal air injection. The majority of the surgeons (66%) reported a low conversion rate to penetrating keratoplasty (<10%), while a section (16%) of corneal surgeons still report a high conversion rate to penetrating keratoplasty (>25%). This suggests the need for multicentric studies in the future with surgeons of variable levels of expertise. It will help highlight the outcome of DALK in a real-life scenario, unlike the past studies that are based on the outcome of a single surgeon with a high level of expertise in this challenging surgery, which often over-estimates the surgical outcome.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Digital Content

Supplementary Content 1: Proforma of the survey circulated among the participants

DALK Surgery Survey

1. How many corneal transplantation surgeries you perform in a year

| | 0-25 | 26-50 | 51-75 | 76-100 | 101-150 | 151-200 | 201-250 | >250 |
|---------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Optical Corneal Transplants | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Therapeutic Corneal Transplants | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

2. Distribution of various techniques among Optical Grafts performed annually.

| | <10% | 10-25% | 26-50% | 51-75% | >75% |
|--------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| PKP | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| DALK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| DSEK / DSAEK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| UT DSAEK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| DMEK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

3. Indications for DALK - Rank them from 1-5 (1 most common, 5 least common)

- Keratoconus including post lasik ectasia & other ectatic conditions.
- Corneal Scar
- Corneal dystrophy
- Infections
- Surface reconstruction

4. Which technique do you prefer for your DALK surgery

| | 0-25% | 26-50% | 51-75% | 75-100% |
|----------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Manual near DM DALK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Big Bubble DALK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Viscoelastic assisted DALK | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

5. What is your preferred anaesthesia for DALK surgery

| | <10% | 10-25% | 26-50% | 51-75% | 75-100% |
|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Local anaesthesia | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| General anaesthesia | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

6. Preferred size of corneal trephine used routinely for DALK

- 7.0 - 7.5
- 7.5-8.0
- 8.0 -8.5
- 8.5-9.0

7. Which corneal trephine do you routinely use for DALK

- Hand held metal trephine
- Hand held guarded depth trephine
- Suction Trephine (Hessberg Baron / Hanna)
- Femtosecond laser
- Other (please specify)

8. What do you prefer for stromal air injection to initiate Big Bubble

- 26G / 27G Needle
- 30G Needle
- Bottom port air injection cannula

9. Do you perform an anterior lamellar keratectomy prior to air injection for Big Bubble

- Yes
- No

10. Do you perform a paracentesis prior to air injection for Big Bubble

- Yes
- No

22. What is your preferred suturing technique in DALK surgery

| | <5% | 5-10% | 11-25% | 26-50% | 51-75% | >75% |
|-------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Interrupted | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Combined Interrupted and Continuous | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Continuous | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

23. Do you use intraoperative keratoscope for suture adjustment during DALK

- Yes
- No

24. If you have encountered perforation during DALK surgery, what do you prefer for tamponade

- Air
- 20% SF6
- 14% C3F8

Other (please specify)

25. If you use air or gas for tamponade, what do you prefer to avoid pupillary block

- Inferior PI
- Keep pupil dilated
- Burp out some air / gas after 1-2 hours

Other (please specify)

26. Have you encountered Urets Zavalia Syndrome after using Air or Gas for tamponade

- Yes
- No

27. Post operative complications following DALK

| | Complication rates |
|--|----------------------|
| Double anterior chamber with micro perforation | <input type="text"/> |
| Double anterior chamber without microperforation | <input type="text"/> |
| Interface infection | <input type="text"/> |
| Non healing epithelial defect | <input type="text"/> |
| Stromal rejection | <input type="text"/> |
| interface vascularisation and lipid keratopathy | <input type="text"/> |
| Graft dehiscence post trauma | <input type="text"/> |
| Urets Zavalia Syndrome | <input type="text"/> |
| Cataract | <input type="text"/> |

28. In your experience the visual outcome of DALK in comparison to PKP

- Same as PKP
- Inferior to PKP
- Superior to PKP

Other (please specify)

29. How many DALK surgeries required to overcome learning curve

- 0-10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-75
- >75

Other (please specify)

Supplementary Content 2: Letter of invitation to participate in the survey

Dear CSI Colleagues,

I hope you are all safe and well during this difficult time.

For surgeons who are currently performing Deep Anterior Lamellar Keratoplasty (DALK) procedure, am reaching out to see if you would be willing to take a brief 10 minute survey on your preferences for DALK techniques, complications and outcomes.

This survey is a part of a research study and will help us understand the current practice pattern among corneal surgeons in India

If you perform DALK surgery and have performed ≥ 10 DALK procedures, please consider taking this anonymous survey, which can be completed electronically using link

<https://www.surveymonkey.com/r/BJ8PZWL>

Please note that participation in this research survey is voluntary.

Thanks in advance for your participation in this survey.

Sincerely,

Rajesh Fogla