The surgical challenges dense brunescent cataracts present


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Dense brunescent cataracts represent a major challenge for surgeons. We performed a literature review focusing on surgical challenges dense brunescent cataracts present. All relevant literature was included in order to describe anatomical landmarks, risk factors, preoperative preparation, surgical techniques (wound creation and burn, capsulorhexis, hydrodissection and hydrodelineation, endothelium protection, phaco-chop techniques), challenges and complications that dense brunescent cataracts surgery present. At the end, we present a speculative viewpoint on how the field will evolve in 5 years. We conclude that with a good preoperative evaluation, surgical planning, advanced protective viscoelastic, modern phacoemulsification machine with optimized parameters and high-quality chop techniques, phacoemulsification assisted or not with femtosecond laser pretreatment can be performed in most of dense brunescent cataracts surgical cases without complications. Knowledge of extracapsular cataract extraction, anterior vitrectomy and keratoplasty techniques is important for surgeons facing these cases because complications can occur.

**KEYWORDS:** cataract • hard dense brunescent • phacoemulsification • surgical challenge • technique

Cataract is one of the major causes of reversible blindness, accounting for about 33% of cases of visual impairment in the world according to the WHO [1]. Since life expectancy has increased in the past decades, the proportion of cataract patients is expected to increase over the next 20 years. The only effective treatment for cataracts is surgery. Surgical outcomes have been increasingly satisfactory with technological advancement. However, some difficult cataracts present challenges that can compromise visual outcomes, especially dense brunescent (or hard) cataracts. This type of cataract is the focus of research to prevent sequelae that the therapeutic procedure can induce.

Dense brunescent cataract surgery represents a major challenge for the surgeon, as this type of cataract has features that increase the risk of intraoperative complications. Surgeons involved in managing cases of hard cataract should be prepared for surgery with knowledge and special surgical skills required to manage these types of cataract. A detailed preoperative exam and surgical plan should be put in place in advance to evaluate the characteristics of cataracts in question, and it is important to be ready for intraoperative challenges.

Regarding this issue, in the present article, we performed a literature review focusing on the surgical challenges that dense brunescent cataracts present. At the end, we present a speculative viewpoint on how the field will evolve in 5 years time.

**Materials & methods**

Eligible articles were identified by a search of the bibliographic database in PubMed using the following combination of search terms: dense brunescent cataracts OR hard cataract OR hard dense cataract. The end of the search date was 1 June 2014. We also checked all the references of relevant reviews and eligible articles that our search retrieved. A systematic review was performed and all relevant literature (in English) was included to describe anatomical alterations, risk factors, preoperative preparation, surgical techniques, challenges and complications that dense brunescent cataracts present. Electronic literature searches identified 108 potentially relevant titles and abstracts for this review. After independent abstract review, 48 records were assessed at the full-text level, of which 17 were included in the major phaco-chop technique and studies review. The inclusion criteria used for this review was to select peer-reviewed articles that
demonstrated surgical techniques in hard dense brunescent cataracts and also studies performed to evaluate outcomes on hard cataract surgeries. We excluded studies that were not relevant after reading the abstract to include in a review of surgical challenges on dense cataract surgery. Finally, a 5-year view related to hard cataracts was prepared.

Results & discussion

Anatomical landmarks

Anatomically, the human lens consists of three distinct structures: capsule, cortex and nucleus. These structures form a lamellate mass and a number of lamellar zones are present physiologically. The fetal nucleus is the most centrally located portion, and it turns into a hard central nucleus as new fibers are laid down over time. The new fibers join each other radially and form a Y-shaped suture line anteriorly and posteriorly [2]. Conventional nucleofractis techniques were developed to crack the lens along the radial suture plane, which is made of adhesions of the fibers. The conventional technique is useful in managing nuclear cataracts. However, in some dense brunescent cataracts, complete nuclear division using conventional techniques is not easy because the radial suture plane of the cataracts tend to have a strongly adhesive quality around the posterior epinucleus [3]. Strong adhesion is able to keep the nuclear fragments attached to each other. When the nucleofractis technique is performed in the case of a hard nucleus, complete division of the nucleus is an essential step in achieving an efficient and safe operation. Incomplete fragmentation may lead to unwanted outcomes during the procedure.

Risk factors

Nuclear cataract is clearly an age-related disease. Besides the most important environmental risk factor of smoking, genetic effects are also important, explaining almost 50% of the variation in the severity of this disease [4]. Other important factors are female sex, diet, exposure to sunlight, estrogen sufficiency or deficiency, diabetes and cardiovascular factors. When a surgeon is faced with a brunescent cataract, some important risk factors have to be ruled out (Figure 1). Trauma has to be investigated, especially in mild-to-young adults with a unilateral hard cataract due to the possibility of having zonular fiber disruption with phacodonesis and lens dislocation and subluxation (Figures 2 & 3). Lens changes often occur as a result of chronic uveitis or associated corticosteroid therapy. The formation of posterior synechiae is common in uveitis, often with thickening of the anterior capsule, which may have an associated fibrous pupillary membrane, resulting in small pupil dilation [5]. Additionally, cataract surgery in an eye that has had a prior vitrectomy can be challenging because the absence of the vitreous can lead to anatomical alterations, such as an overly deep anterior chamber and less support of the crystalline lens. Pseudoexfoliation syndrome is a systemic disease that can lead to challenging cataract surgery with atrophy of the iris at the pupillary margin, poorly dilating pupil, capsular fragility and zonular weakness (Table 1) [6-8].

Preoperative preparation

At first, it is important to know how to calculate the intraocular lens power. In eyes with mature cataract, measuring axial length with optical biometry can be difficult. Thus, ultrasound (US) biometry becomes indispensable [9]. Considering poor fundus visualization, B-scan ultrasonography can play an important role in ruling out retinal issues that may affect visual prognosis after cataract extraction, such as vitreous hemorrhage, membrane formation, maculopathy and retinal detachment. In these cases, a retinal specialist should be aware.

US biomicroscopy can detect zonular involvement in pseudoexfoliation syndrome and may be useful in preoperative planning. This may be important in eyes with posterior synechiae, in which the diagnosis and severity of pseudoexfoliation syndrome cannot be determined by slit-lamp examination (Figures 4 & 5) [10].

An important concern is the type of anesthesia, as dense brunescent cataract surgery may be lengthy with regard to prolonged phaco US time, complications that may occur during surgery, possible conversion to extracapsular cataract extraction (ECCE), absence of capsular bag support and possible

Figure 1. Post-brachytherapy hard cataract. Pre- and post-op.

Figure 2. Post-traumatic hard cataract. Visual acuity = hand motion.

Figure 3. Post-brachytherapy hard cataract. Pre- and post-op.
Surgical techniques
In 1893, Howe presented a report describing some difficulties in satisfactorily completing the final act of extracting hard cataracts [12]. In addition to vitreous loss, hemorrhage into the anterior chamber subsequent to operations for hard cataracts was also demonstrated [13]. Introduced by Kelman in 1967, phacoemulsification with a small ultrasonic tip became the most common modality of cataract surgery [14]. However, phacoemulsification of cataracts with large, hard nuclei may result in an increase in intraoperative complications, such as corneal endothelial injury, posterior capsule rupture and zonular dialysis. To avoid or even minimize complications associated with dense cataract surgery, special surgical techniques should be used and each step must be performed carefully.

Wound creation & burn
Clear corneal incision has become the most desirable way to create cataract surgical wounds. However, no matter how skilled the phaco surgeon is or how good the equipment is, it is possible to encounter a nucleus that is simply too dense to be emulsified. Particularly with a clear corneal incision, moderate stromal whitening and heat shrinkage can result from the higher levels of continuous phaco power typically employed for hard dense nuclei. It is the combination of longer phaco time and greater power that is responsible for overlapping the optic edge of the intraocular lens and the larger axis allows the use of the chopper.

Hydrodissection & hydrodelineation
Hydrodissection to establish nuclear rotation without stressing the zonular network is essential. During this step, an elevating hydrodissection fluid at this point will distend and eventually progress to a posterior capsule rupture [21]. To avoid capsular tear with the chopper or phaco tip (FIGURE 6) [18].

Table 1. Important risk factors to rule out.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trauma</td>
<td>Phacodonesis, subluxation</td>
</tr>
<tr>
<td>Uveitis</td>
<td>Posterior synechiae, pupillary membrane, small pupil</td>
</tr>
<tr>
<td>Prior vitrectomy</td>
<td>Overly deep anterior chamber, posterior capsular rupture</td>
</tr>
<tr>
<td>Pseudoexfoliation</td>
<td>Poorly dilation, zonular weakness</td>
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</table>

Capsulorhexis
A minimum 5 mm pupil dilation to permit an adequate visualization is important to perform a continuous curvilinear capsulorhexis. Prior to injecting OVD, it is advisable to use trypan blue dye for capsular staining, especially in mature nuclear cataract, when a poor red reflex impedes visualization of the anterior capsule, making capsulorhexis difficult and forcing the surgeon to more likely tear its edge with the chopper or phaco tip.

Some operating microscopes have dual control over separate oblique and coaxial illumination sources. This allows the surgeon to turn off the oblique illuminating beam and use only the stereo coaxial beam to dramatically enhance the red reflex for the capsulorhexis step.

Capsulorhexis (7.0 mm × 5.5 mm) may be done to avoid excessive tension in the capsular bag, so the smaller axis is responsible for overlapping the optic edge of the intraocular lens and the larger axis allows the use of the chopper [19,20].

Intraocular lens fixation. For these reasons, injectable anesthesia including retrobulbar, peribulbar and sub-Tenon’s may be considered. Another approach could be topical eye drop application in association with an intracameral injection of lidocaine; however, the surgeon must be very experienced with different techniques to fracture and emulsify the hard dense nucleus throughout the clear corneal incision [11].
block, sensitive and sparing force should be used for creating the fluid wave around the lens while slightly depressing the center of the lens to burp the bag. Multidirectional hydrodissection may be helpful to complete the release of any cortical adhesion.

The natural planes that permit hydrodelineation of the immature cataract, creating a golden ring sign, are occult in a brunescent lens. Surgeons cannot hydrodelineate the brunescent lens, but can still mechanically find this division and expose the nucleus in a circumferential manner, peeling out dense fibers.

Endothelium protection
Hard brunescent nuclei require longer phaco times and higher energy levels. The longer operating time contributes to OVD washout, which is a greater problem than with most typical cases. Dispersive OVDs, such as 3% sodium hyaluronate + 4% chondroitin sulfate (Viscoat) and 3% sodium hyaluronate (Healon EndoCoat) or viscoadaptive and highly retentive OVDs such as 2.3 and 1.4% sodium hyaluronate (Healon 5 and Healon GV, respectively) or 1.65% sodium hyaluronate + 4% chondroitin sulfate (DisCoVisc), if properly utilized, are able to coat and protect the endothelium for longer periods (Table 2) [22].

It is common that OVDs wash away during the procedure, especially when dealing with a brunescent lens. The surgeon should repeatedly recoat the endothelium with dispersive OVD during the phaco.

In hard lens nucleus, the soft-shell technique, which combines cohesive and dispersive viscoelastic substances, is considered safe and effective in protecting corneal endothelial cells during cataract surgery [23].

Phaco-chop techniques
Chopping a very dense nucleus can be difficult to accomplish initially because of the tough nature of the lens material. By replacing sculpting with manual fracture of the nucleus, phaco chop leads to an overall reduction in total US power and time (Table 3).

For hard nuclei, the original divide-and-conquer technique involves breaking the nucleus into quadratic sections [24,25]. Shepherd [26,27] described a variation of this technique, phacoemulsification in situ fracture, in which the fragments are tumbled centrally for emulsification. In 1993, Nagahara [28] presented phaco chop, in which the chopping process splits the nucleus into small wedges along the natural cleavage planes of the nucleus using a phaco probe with a second instrument. Other variations of phaco chop include stop and chop, quick chop, phaco sweep and supracapsular phacoemulsification [29–32].

Olson (2003) [33] showed a series of 18 patients with dense cataract (3+ or 4+ grade) who had 21-gauge microphacoemulsification using Sovereign WhiteStar technology. The technique used was a standard horizontal chop and there were no complications during nucleus removal. Some concerns about the technique were wound burn, maintenance of anterior chamber depth and difficulty in rotating the nucleus. It was suggested that divide and conquer could be safe with microphacoemulsification.

Güell et al. (2004) [34] described a phacoemulsification technique called the phaco rolling technique for soft and medium hard cataracts. After conventional hydrodissection and hydrodelineation are performed, a 15- or 30-degree phaco tip is positioned on the peripheral lens beside the capsulorhexis edge and in contact with the nucleus–epinucleus interface. The lens is then aspirated onto the phaco tip. Phacoemulsification is started with the US energy level limited to 15–25% depending on the nuclear hardness and with linear aspiration power up to 250 mmHg. The phaco tip is slightly displaced to the vertex of the pupil to keep it occluded and the lens is rotated. The phaco tip is placed in the same area and a modified
manipulator is used to keep the lens in a horizontal position during rotational movement.

Vasavada et al. (2004) [35] evaluated in a prospective randomized study with 120 consecutive eyes the difference in consumption of US energy required with NeoSoniX combined with US feature of the Alcon Legacy, in which the phaco tip mechanically oscillates at a frequency of 100 Hz versus US alone, in which the tip moves backward and forward at a frequency of 38,000 Hz. They concluded that the US energy consumption with NeoSoniX US was significantly less than that with US alone, indicating the value of NeoSoniX US in emulsifying hard dense cataracts.

Li et al. (2007) [36] demonstrated in a prospective study with 107 eyes the peripheral radial chop technique to remove hard cataracts. They had six cases of posterior capsule rupture in an early period of study. They concluded that the technique was effective without serious complications in the hands of an experienced surgeon.

Kim (2009) [37] described the decrease-and-conquer technique that aims to separate the endonuclear core from the epinucleus. This is done in three steps: circumferential disassembly, decreasing the central nucleus volume and conquering the remnant.

Kamoi and Mochizuki (2010) [38] showed the phaco forward-chop technique. If the nucleus does not separate into two pieces with the standard phaco chop technique, then it is converted to the forward-chop technique.

Kim et al. (2010) [39] performed a comparison between torsional and longitudinal phaco modes in 102 eyes with moderate and hard cataracts. Torsional phaco showed superior efficiency for moderate cataracts; however, there were no statistically significant differences in hard cataracts. All surgeries were performed using the Infiniti Vision System (Alcon Laboratories). A routine phaco chop technique was used either with the US pulse mode (60 pulses/s) or the torsional continual mode. For the torsional mode, 100% amplitude was selected. For the US pulse mode, a maximum power of 60% and a pulse frequency of 60 pulses per second were selected. The vacuum limit was 400 mmHg and the aspiration flow rate was 40 ml/min. The authors discussed the possibility that the shearing effect might not be as effective as the jackhammer effect in hard cataracts, because US power in torsional phacoemulsification does not act on the nucleus perpendicularly. The harshness of phacoemulsification in hard nucleus samples might be due to more repulsion, resulting in endothelial damage in both phaco modes (Figure 7).

In 2011, a randomized clinical trial was published comparing the efficacy of microincision and small-incision coaxial phacoemulsification in treating hard cataracts using different US power modes [40]. A total of 180 eyes (60 each) were enrolled in three groups, based on the incision size: 1.80, 2.20 and 2.75 mm. Two months postoperatively, there were no statistically significant differences in US time, mean cumulative dissipated energy, incisional corneal thickness and central corneal thickness at 1 week, and the percentage endothelial cell loss at 2 months with continuous mode were statistically significantly higher than with pulse mode and burst mode in all three incision groups. The 2.75-mm incision induced more astigmatism at 2 months and less incisional corneal edema at 1 week than the 1.80 or 2.20 mm incision. The US time, cumulative dissipated energy, incisional corneal thickness and central corneal thickness at 1 week, and the percentage endothelial cell loss at 2 months with continuous mode were statistically significantly higher than with pulse mode and burst mode in all three incision groups.

Fakhry and Shazly (2011) [41] compared torsional versus combined torsional and conventional US modes in hard cataract surgery and concluded that both modes are safe; however, the pure torsional mode showed less US energy used. They also recommended further studies involving the use of an intelligent phaco option with torsional mode, as it might have the same efficiency without the repulsion effect of longitudinal US when combined with the torsional US mode.

Kim and Jang (2012) [42] described the drill-and-chop technique, a technique to improve the control and safety of vertical chopping during hard cataract surgery. Whereas the conventional vertical chop technique uses a sharp vertical chopper, the proposed technique used a short blunt chopper. This required

### Table 2. Endothelium protection: dispersive OVDs.

<table>
<thead>
<tr>
<th>OVD</th>
<th>Composition</th>
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<tbody>
<tr>
<td>Viscoat</td>
<td>3% sodium hyaluronate + 4% chondroitin sulfate</td>
</tr>
<tr>
<td>Healon EndoCoat</td>
<td>3% sodium hyaluronate</td>
</tr>
<tr>
<td>Healon 5</td>
<td>2.3% sodium hyaluronate</td>
</tr>
<tr>
<td>DisCoVisc</td>
<td>1.65% sodium hyaluronate + 4% chondroitin sulfate</td>
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</table>

OVD: Ophthalmic viscosurgical device.
Table 3. Major phaco-chop techniques and studies in hard cataracts.

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Type</th>
<th>Brief description</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shepherd (1991)</td>
<td>Technique</td>
<td>In situ fracture</td>
<td>[26]</td>
</tr>
<tr>
<td>Nagahara (1993)</td>
<td>Technique</td>
<td>Phaco chop</td>
<td>[27]</td>
</tr>
<tr>
<td>Koch and Katzen (1994)</td>
<td>Technique</td>
<td>Stop and chop</td>
<td>[29]</td>
</tr>
<tr>
<td>Gimbel (1995)</td>
<td>Technique</td>
<td>Phaco sweep</td>
<td>[31]</td>
</tr>
<tr>
<td>Olson (2004)</td>
<td>Prospective</td>
<td>21-gauge microemulsification with Sovereign</td>
<td>[33]</td>
</tr>
<tr>
<td>Güell (2004)</td>
<td>Technique</td>
<td>Phaco rolling</td>
<td>[34]</td>
</tr>
<tr>
<td>Li et al. (2007)</td>
<td>Prospective</td>
<td>Peripheral radial chop</td>
<td>[36]</td>
</tr>
<tr>
<td>Kim (2010)</td>
<td>Technique</td>
<td>Decrease and conquer</td>
<td>[37]</td>
</tr>
<tr>
<td>Kamoi and Mochizuki (2010)</td>
<td>Technique</td>
<td>Phaco forward-chop</td>
<td>[38]</td>
</tr>
<tr>
<td>Kim et al. (2010)</td>
<td>Prospective</td>
<td>Torsional and longitudinal phaco modes with Infinity</td>
<td>[39]</td>
</tr>
<tr>
<td>Kim (2011)</td>
<td>Prospective</td>
<td>Micro vs small incisions with different power modes</td>
<td>[40]</td>
</tr>
<tr>
<td>Fakhry and El Shazly (2011)</td>
<td>Prospective</td>
<td>Torsional and conventional phaco modes with Infinity</td>
<td>[41]</td>
</tr>
<tr>
<td>Kim and Jang (2012)</td>
<td>Technique</td>
<td>Drill and chop</td>
<td>[42]</td>
</tr>
<tr>
<td>Falabella et al. (2013)</td>
<td>Technique</td>
<td>Retrochop</td>
<td>[43]</td>
</tr>
<tr>
<td>Park et al. (2013)</td>
<td>Prospective</td>
<td>Phaco chop vs divide and conquer vs stop and chop</td>
<td>[44]</td>
</tr>
</tbody>
</table>

A 7.0 × 5.5 mm oval capsulorhexis is performed, with the larger axis pointing toward the paracentesis [43,44]. The phaco machine is set at a power of 70% (40 kHz handpieces) or 30% (32 kHz handpieces) with a pulse mode of 80 pulses per second, duty cycle of 70% and bottle height of 120 cm. With a peristaltic pump, the vacuum is set at 400 mmHg and the flow rate at 50 cc/min (Infinity, Alcon Laboratories, Inc.); with a Venturi pump, the vacuum is set at 300 mmHg (Sovereign, Bausch & Lomb). Once grabbed with the phaco tip, the nucleus is tilted to expose part of the posterior face, creating room for the retrochopper. This maneuver, if properly done, creates a fracture that starts at the posterior portion of the nucleus and impales the nucleus toward the anterior portion.

Park et al. (2013) [44] performed a randomized trial with 135 eyes to compare the outcomes of coaxial 2.2-mm microincision cataract surgery with three phaco techniques (phaco-chop, divide-and-conquer and stop-and-chop) according to cataract density. They concluded that all three techniques might be effective for coaxial microincision cataract surgery in mild and moderate cataracts. However, in eyes with hard cataract having coaxial microincision cataract surgery, the phaco-chop technique can be more effective for lens removal, with less corneal endothelial damage than the divide-and-conquer and stop-and-chop techniques.

Surgical challenges & complications

It is known that hard cataract surgery presents challenges and is more susceptible to complications. First of all, on a preoperative exam, a surgeon should be aware if some degree of zonular fragility is present with or without phacodonesis. The iris morphology should be investigated, especially when atrophic areas are seen and poor pupillary dilation is achieved. For these challenges, iris hooks and capsule tension ring should be prepared for the surgery. The surgeon should advise patients preoperatively of the need for a possible second surgery [45].

The Swedish Capsule Rupture Study Group reported that preoperative conditions associated with a capsule complication were previous trauma, white and brunescent/hard cataract, and phacodonesis. The intraoperative factors of loose zonules, the use of trypan blue and miosis were all statistically significantly overrepresented in the capsule complication group. The same was true for eyes operated on by surgeons with the least experience. They concluded that by preoperatively identifying cataract cases with the identified risk factors and allocating them to surgeons with the longest experience, the number of capsule complications could be kept low. Operating early in the course of the disease to prevent the cataract from becoming a poor surgical risk and improving training of junior surgeons should further reduce the frequency of capsule complications [46].

One concern after hard cataract surgery is which technique produces more corneal endothelial cellular damage: phacoemulsification or ECCE. Bourne et al. (2004) [47] performed a randomized controlled trial with 433 patients followed for 1 year to compare phaco versus ECCE. Increased brunescence...
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of cataracts was associated with significantly more cell loss (independent of the effect of age) in their study. A hard cataract doubled the risk of severe (≥15%) cell loss. Firmness of the nucleus was the most significant risk factor for endothelial injury, suggesting that mechanical contact with nuclear fragments in phacoemulsification produced the endothelial injury. This might be indirectly represented by the phacoemulsification time. It was interesting that complications of surgery such as capsule rupture and vitreous loss carried a 2.6-times risk of severe (≥15%) cell loss at 1 year in this study. They concluded that increased risk of severe cell loss with phacoemulsification in patients with hard cataracts suggests that phacoemulsification may not be the optimal procedure in these cases and that ECCE should be preferred.

Stumpf and Nose (2009) [48] published a prospective trial with 41 patients comparing both techniques for hard cataracts. They did not find a statistically significant difference between both techniques related to endothelial damage. It is important to address that with a good preoperative evaluation, surgical planning, advanced protective viscoelastic modern phacoemulsification machine with optimized parameters and high-quality chop techniques, phacoemulsification can be performed in most of the dense brunescent cataracts cases.

Conclusion
We conclude that with a good preoperative evaluation, surgical planning, advanced protective viscoelastic, modern phacoemulsification machine with optimized parameters and high-quality chop techniques, phacoemulsification assisted or not with FSL pretreatment can be performed in most of dense brunescent cataracts surgical cases without complications.

Expert commentary
Dense brunescent cataracts represent a major challenge for surgeons. It is crucial for all surgeons facing these cases to be aware of anatomical landmarks, risk factors, preoperative preparation, surgical techniques (wound creation and burn, capsulorhexis, hydrodissection and hydrodelineation, endothelium protection, phaco-chop techniques), challenges and complications that dense brunescent cataracts surgery present.

We still believe that knowledge of ECCE, small incision cataract surgery, anterior vitrectomy and keratoplasty techniques is important for surgeons faced with these cases because complications can occur.

There is also very little evidence to show that FLS cataract surgery can facilitate hard cataract surgery [30,53]. We conclude that the use of the new technology can be well applied by skilled surgeons; however, the scarcity of studies has to be acknowledged and more data published to facilitate the management of the technology in such cases.

Five-year view
Cataract surgeries with femtosecond laser (FSL) pretreatment will result in a significant reduction of effective phacoemulsification time, what may be achieved using better surgical techniques and lens fragmentation patterns [49]. While the impact of reduced phacoemulsification energy on the corneal endothelium is still being investigated, FSL pretreatment should be recommended, especially for those cases with low endothelial cell density at baseline, including after penetrating keratoplasty, mature cataracts and some post-refractive surgeries.

FSL fragmentation with different grid sizes affects effective phaco time in cataract surgery [50]. Though there are standard parameters to be used with each FSL platform, it is important to do a precise preoperative assessment and to set intraoperative parameters based on each case, including energy and delta values for fragmentation (based on lens size and nuclear sclerosis) and anterior capsulotomy and centration of capsulotomy and corneal incisions. We believe that nuclear sclerosis grade will be measured with automated technology, such as Scheimpflug camera [51] or optical coherence tomography, and the data will be transferred to the FSL system that will be capable of adjusting laser parameters and grid patterns to optimize nuclear fragmentation prior to phacoemulsification. Surgical outcomes and safety of FSL cataract surgery will improve significantly with greater surgeon experience, development of modified techniques and improved technology [52]. FSL cataract surgery allows a significant reduction in effective phacoemulsification time, which correlates positively with the preoperative lens opacity [53].

However, we might speculate that well-trained surgeons, who are capable of performing ECCE, penetrating keratoplasty and nucleus removal into the vitreous, would be ideal for hard brunescent cataract surgical cases, no matter how technology will improve.

It is noteworthy to mention that small incision cataract surgery is an essential technique used in hard, brunescent cataract cases and in the cataract cases of vitrectomized eyes in which phacoemulsification may be considered risky [54-58]. The sandwich technique is reported to present some advantages in mature cataract cases. In this method, the nucleus is firmly grasped between two instruments, irrigating vectis and spatula.
So an incision length of a diameter of the nucleus or 1 mm more is enough to be able to extract the nucleus out to the eye. Furthermore, it is considered that removing the nucleus via sandwiching it firmly between two instruments prevents the corneal endothelium more than extracting it via just only vectis or exerting a pressure on the scleral wound lip, since the spatula in front of the nucleus would ensure it stays away from the endothelium [59-61]. From a speculative viewpoint on how the field will evolve in 5 years, we consider that small incision cataract surgery will continue to be a valuable option, particularly for surgeons who do not have plenty of instrumental possibilities to carry out phacoemulsification in undeveloped regions.

**Financial & competing interests disclosure**
The authors have no relevant affiliations or financial involvement with any organization or entity in a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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**Key issues**

- Risk factors: Important to rule out trauma, uveitis, prior vitrectomy and pseudoexfoliation syndrome.
- Preoperative preparation: Ultrasound biomicroscopy will be indispensable. B-scan ultrasonography will also be important to rule out retinal issues. Ultrasound biomicroscopy can detect zonular involvement. Injectable anesthesia may be considered.
- Wound creation and burn: Nucleus that is simply too dense to be emulsified, convert to extracapsular cataract extraction can be safely. A way to reduce energy and heat during emulsification is by combining chopping with lower phaco duty cycle.
- Capsulorhexis: Advisable to use trypan blue dye for capsular staining. An oval capsulorhexis may be done to avoid excessive tension in the capsular bag.
- Hydrodissection and hydrodelineation: To avoid capsular block, sensitive and sparing force should be used in creating the fluid wave around the lens while slightly depressing the center of the lens to burp the bag.
- Endothelium protection: The surgeon should repeatedly recoat the endothelium with dispersive ophthalmic viscosurgical device during the phaco.
- Phaco-chop techniques: Every surgeon has his or her preferable technique. The knowledge of different approaches is advisable to improve surgical skills, especially with difficult cases.
- Surgical challenges and complications: Iris hooks and capsule tension ring should be prepared for the surgery. Surgeon should advise patients preoperatively of the possible need for a second surgery.
- Five-year view: Skilled surgeons, who are capable of performing extracapsular cataract extraction, penetrating keratoplasty and nucleus removal into the vitreous, would be ideal for hard brunescent cataract surgical cases, no matter how technology will improve.

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**References**

Papers of special note have been highlighted as:

- of interest
- **of considerable interest**


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- Both trypan blue 1% and indocyanine green 0.5% are safe in assisting visualization of the anterior capsule during phacoemulsification of mature cataracts.


**This study describes a recently developed chopper, the retrochopper, and a technique for managing black and brunescent cataracts, called retrochop technique.**


**The phaco-chop technique can be more effective for lens removal, with less corneal endothelial damage, in hard cataracts.**


**Preoperatively identifying cataract cases with the identified risk factors and allocating them to surgeons with the longest experience, the number of capsule complications could be kept low.**

48. Stumpf S, Nosé W. Endothelial damage after planned extracapsular cataract extraction and phacoemulsification of hard cataracts. Arq Bras Oftalmol 2006;69:491-6


- The surgical outcomes and safety of laser cataract surgery improved significantly with greater surgeon experience, development of modified techniques and improved technology.


- Demonstrates that with an increased preoperative nucleus opacification system based on Scheimpflug camera, a significant reduction in effective phacoemulsification time was allowed with femtosecond laser-assisted cataract surgery.


