Expansion Vibration Lipofilling: A New Technique in Large-Volume Fat Transplantation

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Background: Despite rapid growth, gluteal fat transplantation is an operation in search of science and a teachable technique. Long operating times, tedious syringe transfers, inability to shape the recipient site, and the risk of fat embolism all headline as impediments to clinical adoption of the procedure. Expansion vibration lipofilling is a syringe-free surgical strategy that is a logical extension of Separation, Aspiration, and Fat Equalization (SAFELipo). In expansion vibration lipofilling, there is simultaneous disruption of recipient-site connective tissue, internal expansion using exploded-tip cannulas, and backfilling of these spaces with roller pump–propelled fat.

Methods: Two thousand four hundred nineteen consecutive cases of expansion vibration lipofilling fat transplantation to the buttocks were reviewed. Average follow-up was 12 months. The technique of expansion vibration lipofilling is dependent on the use of larger caliber cannulas attached to a roller pump and to an oscillatory power-assisted liposuction device, which is less labor-intensive, potentially allowing for better knowledge of cannula-tip location at all times during the procedure.

Results: Operating times averaged 1 hour 40 minutes. The average volume of fat inserted was 1003 cc. Complications included donor-site seroma, infection, and one pulmonary embolism treated with anticoagulation. There were no cases of fat embolism or death.

Conclusions: Expansion vibration lipofilling is a new method for large-volume fat transplantation. Avoidance of fatal fat emboli demands a surgeon's complete knowledge of cannula tip location at all times during the procedure. Syringe-free, larger caliber, and less flexible cannulas, combined with techniques requiring less operator upper extremity effort resulting in less fatigue, may contribute to avoidance of this dreadful complication. (*Plast. Reconstr. Surg.* 141: 639e, 2018.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, IV.

Despite successful volume retention in fat grafting to the buttocks,[1] superficial and deep contour irregularities continue to affect results. We stress the distinction between restoration of deflated volumes versus volume increase and shape change in large-volume fat transplantation. Despite the larger capacity of the buttocks and the greater ability to place larger volumes into it, the use of the Coleman technique requires syringe injection and percutaneous release of ligamentous bands, or "Rigottomies," where expansion of specific areas of the buttock to effect shape change is required. Rigottomies carry potential morbidity and can cause severe buttock ptosis when used in conjunction with the Coleman technique.

Fat centrifugation, syringe transfer, and microdroplet injection can result in extended operative times, reducing the ability to perform concurrent procedures, and may represent an additional safety risk for elective cosmetic surgery patients undergoing general anesthesia.[2] Lastly, buttock augmentation with fat transplantation carries a risk of fatal fat embolism, making it a procedure that must be

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carefully analyzed with regard to anatomical, technical, and instrumentation considerations.

Separation, Aspiration, and Fat Equalization (SAFELipo; SAFELipo, LLC, Las Vegas, Nev.), has been described as an alternative to conventional liposuction.[3] The separation of subcutaneous tissue in SAFELipo allows for mechanical emulsification of targeted fat, without creating avulsion injury to blood vessels or the supporting stromal network. The separated fat is preferentially aspirated, avoiding damage to unintended structures. Lastly, the smooth layer of "local fat grafts" created during fat equalization smooths the target area while also preventing adherence or collapse of the dermis down to fascia, reducing the risk of creating a contour deformity.[4]

The purpose of the present communication is to introduce expansion vibration lipofilling. Expansion vibration lipofilling is a logical extension of SAFELipo beyond simple fat removal, applied to fat transplantation and completing an integrated, comprehensive approach to fat management. We herein describe clinical situations where these techniques might contribute to better and safer clinical outcomes.

PATIENTS AND METHODS

Over a 5-year period, the authors performed 2419 consecutive cases of buttock augmentation using autologous fat. Patient age ranged from 16 to 68 years, and the patients underwent fat harvesting using tumescent technique and machine aspiration. SAFELipo was performed in donor areas.

In the first 109 cases, performed by one of the authors (D.D.V.), syringe-based techniques that have been previously described[5] used 60-cc syringes attached to a 14-gauge blunt-tip cannula (Coleman Cannula; Mentor, Inc., Santa Barbara, Calif.). Ligamentous bands, predominantly cellulite, tended to worsen with fat injection and were treated with percutaneous needle band release Rigottomy.

Although the aforementioned techniques yielded reliable volumetric results, in many cases there was inability to convey shape change in the inferolateral buttock "hip" area when desired. Inadequate needle-band release resulted in residual depressions and difficulty creating convexity to these buttock areas. Conversely, Rigottomies after fat transplantation resulted in several cases of ptotic, loose buttock skin that eventually required buttock lifting and additional surgery (Fig. 1).

In 2012, our technique changed. Instead of a two-stage technique of syringe injection followed by percutaneous ligamentous band release, a simultaneous system of syringe-free, "exploded-tip" large cannula lipofilling and band release was used.

Expansion Vibration Lipofilling

Positioning and Approach (D.D.V.)

After donor tumescence and liposuction of sufficient volumes in the supine position, patients were placed prone and flexed at 30 degrees. Silicone rolls were placed under the anterior superior iliac spine to increase hip flexion. Two incisions were used for transplantation access.

Fig. 1. (*Left*) Lateral view of a 37-year-old patient 1 week and (*center*) 1 month after gluteal fat grafting using Rigottomies. Percutaneous needle release of ligamentous bands in this case resulted in severe buttock ptosis that required buttock lift (*right*).

A 4-mm incision in the natal cleft and a similar incision in each infragluteal crease were used to approach the buttock from above and below, respectively. Patient flexion allowed for tangential subcutaneous grafting using 4- to 5-mm-diameter, 40-cm-long cannulas, potentially reducing surgical misadventure into deeper structures. The robust nature of these cannulas also facilitates deliberate and upward directional grafting (Fig. 2).

Positioning and Approach (S.W.)

After superwet infiltration, liposuction was performed in three positions (i.e., supine, lateral, and lateral). Expansion vibration lipofilling was performed while the patient was in each lateral position. Typically, two access points were used on each side (i.e., inferomedial gluteal fold and inferolateral sacral) for access from below and above, respectively, and with one optional access point (lowest point of hip at the midaxillary line) for access from the lateral buttock. The patient was similarly maintained in slight hip flexion, using angled, exploded-tip, 4-mm cannulas (20-degree angle placed 10 cm from the cannula tip) (Fig. 3).

Anatomy and Avoidance of Critical Structures

From the anesthesia nerve block literature,[6,7] the sacral hiatus, the posterior superior iliac crest, and the greater trochanter were identified by bony palpation. The letter A was marked between these three structures. Where the horizontal line of the letter A intersected with the long diagonal arms of the letter A, the topographic locations of the superior gluteal vascular bundle superiorly and the sciatic nerve inferiorly were identified. In these areas, direct intramuscular injection was avoided in a zone of approximately 3 cm peripheral to these structures (Fig. 4).

Instrumentation Setup and Technique

In expansion vibration lipofilling, 4- to 5-mm exploded-tip cannulas (Surgistem Technologies, Boston, Mass.) were used and were attached to a power-assisted liposuction unit. The tubing attached to the cannula was used in a retrograde fashion as a conduit to propel fat out the tip of the cannula. Fat flow was induced by the use of a peristaltic pump from a canister filled with fat, and flow was automatically selected at a constant flow rate of 200 to 300 cc/minute (Fig. 5).

Fig. 2. Patient positioning and instrumentation to avoid surgical misadventure. Flexion of the table and robust long cannulas allow for convexification of the buttock and deliberate superficial directed subcutaneous grafting, respectively.

Fig. 3. Expansion vibration lipofilling performed by one of the authors (S.W.) in the lateral decubitus position.

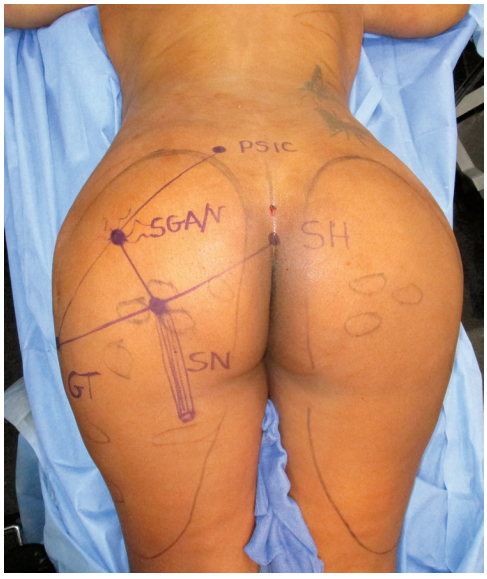

Fig. 4. Knowledge of anatomical location and avoidance of deep structures. Using bony landmarks, the superior gluteal vessels (*SGA/V*) and sciatic nerve plexus (*SN*) can be localized and avoided during surgery by maintaining a subcutaneous cannula tip position in the zone overlying these structures. *PSIC*, posterior superior iliac crest; *SH*, sacral hiatus; *GT*, greater trochanter.

In areas of excessive ligamentous bands, such as the midlateral and inferolateral buttock, fat flow was reduced or halted temporarily while the exploded-tip cannulas were manipulated to loosen or release bands and diminish resistance in tight areas. In this manner, simultaneous filling, expansion, and shaping could be performed uniformly without the use of percutaneous band release.[8] Patients were managed postoperatively with hydration, compression garments, foam compression, and avoidance of sitting for a minimum of 3 weeks.

Two thousand three hundred ten patients were treated with a combination of SAFELipo and expansion vibration lipofilling techniques for augmentation of the buttock over a 5-year period. Transplanted volumes ranged from 275 to 4400 cc per buttock, with a weighted average between surgeons of 1003 cc for each buttock. For isolated fat transplantation cases to the buttock without concomitant procedures, operative times ranged from 50 minutes to 2 hours 15 minutes, for an average of 1 hour 40 minutes. Follow-up ranged from 9 to 24 months, with an average of 12 months.

RESULTS

Intraoperative Complications

There was one intraoperative allergic drug reaction. One patient experienced transient severe hypoxemia in the prone position because of right mainstem migration of the endotracheal tube. There were no cases of intraoperative fat embolism.

Postoperative Complications

Nine cases of abdominal donor-site seromas required serial aspirations in the office. Of these, two patients had undergone previous abdominoplasty and five had undergone concomitant abdominoplasty. Five patients had sterile fat abscesses that required percutaneous drainage in the office. Five patients developed donor-site cellulitis, three of whom had cellulitis of the abdominoplasty flap, all of which resolved with oral antibiotics. One patient experienced a deep venous thrombosis and pulmonary embolus on postoperative day 12 diagnosed by computed tomography that required hospital readmission and that responded to intravenous and later oral anticoagulation, which led to a full recovery. Two patients felt their buttocks were too large and had follow-up buttock liposuction

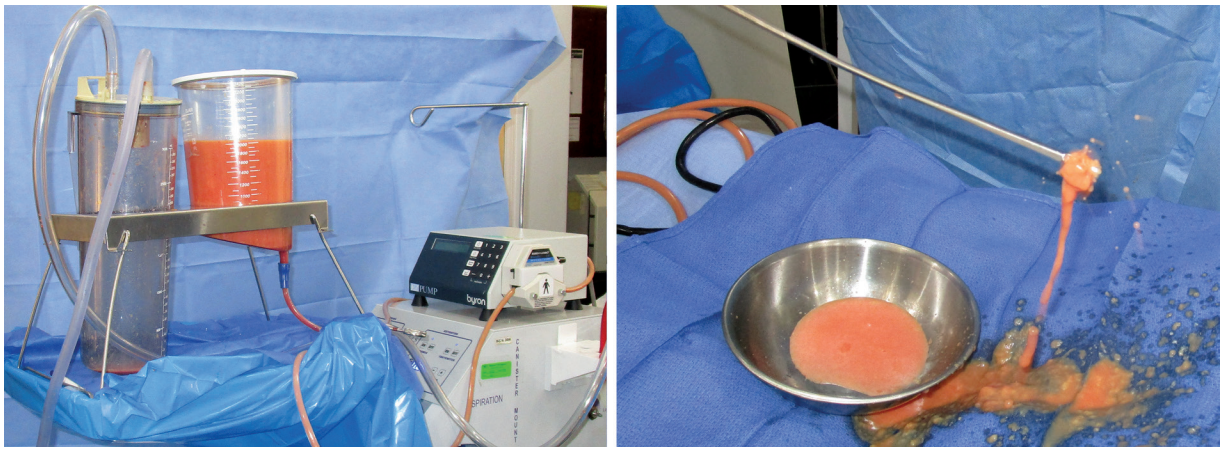

Fig. 5. Instrumentation setup for expansion vibration lipofilling. Canister spigot, tubing, and cannula size are all of equal diameter to avoid any one area of high resistance (bottleneck) and resultant shear, both of which are commonly seen in syringe-based techniques of fat transplantation.

Fig. 6. Expansion vibration lipofilling was used for shape control to alleviate silhouette asymmetry. (*Left*) Before buttock augmentation. (*Right*) On-table view after 2800 cc was inserted into each side of this 37-year-old patient, showing better silhouette symmetry and hip width/convexity.

that alleviated this problem. There were no cases of postoperative fat embolism.

Aesthetic Results

Overall, there was increased ability to impart targeted shape change to (1) alleviate asymmetry, (2) widen the midlateral and inferolateral buttock contour "hip" on the anteroposterior view, and (3) impart increased buttock convexity and projection on the lateral view. Representative results are shown in Figures 6 through 9.

DISCUSSION

History

In the 1990s, buttock lipoaugmentation[9] was dismissed as a simple operation requiring no special instrumentation[10] and was considered a questionable procedure. Lack of adoption was fueled by lack of results, because of the inability to accurately quantify volume.[11,12] Despite its popularity, the classic Coleman technique for fat grafting to the buttocks may not result in an effective or

Fig. 7. Expansion vibration lipofilling increased buttock convexity and projection. (*Left*) Preoperative view. (*Right*) One year after combined abdominoplasty, liposuction, and expansion vibration lipofilling fat transplantation to the buttocks in this 42-year-old patient showing increased buttocks convexity and projection.

Fig. 8. Expansion vibration lipofilling was used for widening of midlateral and inferolateral areas to alter the waist-to-hip ratio. (*Left*) A 24-year-old patient before buttock augmentation. (*Right*) One-year postoperative view after 1900 cc fat in each buttock, showing a waist-to-hip ratio of 0.66. Note the uninterrupted curvature of the waist-hip-thigh contour.

Fig. 9. Expansion vibration lipofilling was used for widening of hip contour in a tight recipient site to alter the waist-to-hip ratio. (*Left*) Before liposuction and buttock augmentation. (*Right*) One-year postoperative view after 2200 cc inserted on each side, showing a waist-to-hip ratio of 0.7

efficient operation. By wedging microdroplets of fat on axial withdrawal of a 12- to 14-gauge cannula, recipient-site interstitial pressures may rise quickly, setting limitations on graft volumes. Furthermore, this technique does not affect significant recipient-site shape change. Power-assisted equalization of the recipient site was first described by Wall,[13,14] followed by recent reports of a syringed-based technique.[15]

Expansion Vibration Lipofilling Considerations

Expansion vibration lipofilling allows for recipient-site expansion by using exploded-tip injection cannulas, creating a wider potential space and ability to separate and equalize tissue. Concurrently, fat is deposited into the expanded area with the exploded-tip cannula, effectively serving as a stent followed by the immediate deposition of graft to occupy the stented space. The exploded portion of the cannula, typically two times the diameter of a typical 4-mm cannula, creates four times more space as it moves through the target zone (using πr^2). In addition, recipient-site expansion grafting is also significantly enhanced by the use of vibration (reciprocation) of the cannula, as the differential pressure zones created by the exploded "wings" of the cannula are magnified by movement (vibration).

From the steps learned in SAFELipo, expansion vibration lipofilling can be envisioned as a logical extension of "equalization" of the recipient site during fat transplantation. In an abundance or excess of graft, as is seen during lipofilling with exploded-tip cannulas, oscillations allow homogeneous distribution of fat lobules. Angled cannulas, rapid oscillations, larger diameters, and quicker flow rates allow for further "reach" of the cannula, resulting in more extensive and thorough equalization of recipient-site tissue, analogous to spray painting versus painting with a brush. More thorough and dispersed fat translates to more surface area contact between grafted fat lobules and recipient tissue.

Role of Expansion in Lipofilling: Aesthetic Sequelae

Fat cells are subject to shear injury[16] and do not act as tissue expanders to expand constricted areas. The classic Coleman technique involves the injectional wedging of fat into recipient sites, as "microdroplets,[17] without active expansion of the recipient site per se. Therefore, fat injected into depressed concavities using the Coleman technique can traverse to areas of lower resistance, failing to improve contour deformities. In most cases, the deformity is not treated, and surrounding

Fig. 10. Tombstone deformity. Posterior view of a patient who had fat injected into lateral buttocks using syringe-based techniques. The result is an unaesthetic buttock deformity resembling a tombstone.

areas with greater tissue compliance receive the fat, resulting in additional deformities.

We define the "tombstone deformity" as a classic example of inadequate release and expansion of the midlateral buttock hollow, associated with fat transplantation to the buttocks using syringe-based techniques. Unless this area is aggressively expanded and backfilled with fat, fat simply injected into this area will cause fat to migrate, most commonly superolaterally, to the hip area, resulting in a square buttock shape, or the tombstone deformity (Fig. 10).

In the classic Coleman technique, fat is inserted using small-gauge needles, wedged into existing tissue without any disruption of the recipient-site architecture. This puts pressure on adipocyte lobules and limits the expansion of the volume of the recipient site. In this scenario, adipocytes are asked to play the role of tissue expanders, finding a blood supply and at the same time surviving by diffusion. What may make sense in lower volume, higher compliance situations such as the deflated aging face simply do not make sense in large-volume recipient sites such as the buttock. Although we have previously articulated the differences between small-volume and large-volume fat transplantation,[18] we make the further distinction here with regard to the restoration of volume lost, which is a completely different recipient site from the augmentation of volume that never existed (Fig. 11).

Fat Embolism

Apart from the aforementioned aesthetic limitations of nonexpansion syringe-based techniques in large-volume fat transplantation, there may be serious safety issues in buttock fat grafting.[19,20] Description of deaths caused by fat embolism[21]

Fig. 11. Small-volume (30 cc) restoration of an aging, deflated face is a very different exercise from a large-volume increase and shape change to buttocks using 4400 cc of fat. Different recipient sites require different instruments, operative strategy, and surgical technique.

were reported in conjunction with nine cases of large-volume fat transplantation, all using syringe-based lipoinjection. In this article, the recommendation of the author, and follow-on letters to the editor,[22] were to "use only blunt cannulas 3 mm in diameter attached to low-pressure syringes."

To achieve fat emboli on this macroscopic basis, fat must enter the venous system in a significant volume as to obstruct critical segments of the cardiopulmonary circulation. We posit two mechanisms for achieving this:

1. Cannulation injection theory: A significant sized vein, such as the superior gluteal vein, is directly cannulated as a large bolus of fat is actively injected into the venous system.
2. Laceration siphon theory: Injury to a large vein occurs because of direct venipuncture or indirect tearing, and ensuing high-pressure fat passively flows into the lower pressure venous system over time, as more fat is transplanted.

Although both theories are possible, laceration/siphon seems more plausible because of the constant movement of a cannula during lipoinjection, which would make cannulation/injection less likely. To summarize, the two conditions necessary for a fat embolism are venous injury and a high-pressure state.

Therefore, to reduce or eliminate the risk of fat embolism, one must eliminate one of the two causal factors above. Because it is not possible to eliminate high-pressure states during fat transfer, the only certain way to avoid the risk of fat embolism is to avoid venous injury during fat transplantation.

Avoidance of venous injury requires two key components: a complete understanding of the anatomy and a complete knowledge of where the tip of the cannula is in relation to these veins—at all times. Although the first is relatively easy to learn, the latter is often not possible because of "flexibility misguidance."

Reduction in extremity proprioception with muscular fatigue has been well documented in the orthopedic literature.[23,24] During syringe-based grafting, surgeons rely on their operating extremity to simultaneously perform three critical neurologic functions: (1) axial "back-and-forth" motion by shoulder and elbow muscles; (2) propulsion of syringe flow using hand intrinsic muscles; and (3) sensory proprioception of the cannula tip's location. Sometimes, both hands are manipulating the syringe during injection, further decreasing proprioceptive feedback of the location of the cannula. A flexible cannula, such as a 14- or 16-gauge cannula, can be subject to deformational bend on encountering resistant tissue. On axial penetration, a slight bend in a flexible cannula, or instability in its cannula/syringe (Luer-Lok; Becton, Dickinson & Co., Franklin Lakes, N.J.) junction will continue to curve in the direction of the bend, leading to deeper and deeper tissue planes despite a superficial orientation of the syringe by the operating surgeon. We define this as flexibility misguidance which, in addition to muscular fatigue, may explain why some surgeons actually inject deeper than they intend to or deeper than they think.

In contrast, peristaltic pump-propulsion of fat in expansion vibration lipofilling eliminates the need for hand intrinsics. Vibration through tissue minimizes or eliminates the need for forceful axial back-and-forth arm motion, allowing the surgeon to concentrate solely on the tactile feedback of the cannula tip and its location in the recipient-site tissue. In no cases of known or reported fat embolism during large-volume fat transplantation to the buttocks to date has the technique of expansion vibration lipofilling been used (Fig. 12).

Fig. 12. Flexibility misguidance. On axial penetration, a slight bend in a flexible cannula or the syringe/cannula junction will continue to curve in the direction of the bend, leading to deeper and deeper tissue planes despite a superficial direction of the syringe by the operating surgeon. During syringe-based fat grafting, the surgeon's arm must perform three neurologic functions: (1) axial motion (elbow, shoulder), (2) syringe pressure motion (hand intrinsics), and (3) proprioception as to the exact location of the cannula tip. Fatigue, upper extremity neurologic demands, and flexibility misguidance associated with these syringe-based techniques may contribute to misadventure and injury to deeper structures.

The use of a rigid, larger diameter (4 to 5 mm), vibrating, exploding-tip cannula when grafting fat to the buttock theoretically provides six distinct potential advantages. First, the exploded tip provides acute expansion of the recipient-site space, allowing fat to be deposited with less interstitial pressure. Second, the three or four large holes of the exploded tip provide an acute increase in surface area for fat to egress, reducing intraluminal flow pressure and drag. Third, the larger diameter of the cannula makes its larger, blunter tip less likely to perforate a venous structure. Fourth, its stiffer nature promotes deliberate directional grafting and minimizes or eliminates flexibility misadventure seen in smaller gauge cannulas. Fifth, a fixed-angle cannula can be rotated to increase cannula excursion and efficiency using fewer passes, and also allows it to be oriented superficially to minimize deeper tissue penetration. Finally, the vibrational effect allows for better tissue penetration with less axial pressure and force without the tissue trauma of higher energy devices.[25]

Power-assisted liposuction devices were introduced 20 years ago for liposuction. They were never described to propel fat in fat transplantation. The off-label use of these oscillatory devices is hereby recognized, as is the use of lobules of fat on the order of 1 to 4 mm in diameter, which are directly a function of the hole size of the harvesting cannulas used. Although the size of these fat lobules violates the "2-mm rule," first described as the largest lobular size of fat that could survive by diffusion and imbibition of oxygen,[26,27] in a practical sense, fat lobular sizes in this series of patients ranged from 500 μm to over 4 mm, and the long-term volumetric results do not evidence significant cases of clinical fat necrosis.

CONCLUSIONS

Fat grafting to the buttocks, once thought to be a simple operation, is emerging as a series of sophisticated maneuvers, each of which requires proper instrumentation, techniques, and operative strategies, including respect for deep anatomical structures and proper patient positioning. The most optimal maneuvers for buttock fat transplantation may not be the same as those we have seen to be so useful in the face.

In the classic fat transplantation triad of donor harvest, processing of graft, and the transplantation event, great investment in intellectual property, investment capital, and marketing efforts have been made in technology-rich harvesting systems and fat-processing systems. Meanwhile, little technological innovation has been made in the transplantation of fat or in postgraft shaping. This is partly because of the industry's focus on high-price-point disposables that can be marketed through existing distribution channels, the lack of clinical awareness on the part of those who design and conceptualize fat technologies, and physicians who help promote them.

We define expansion vibration lipofilling as a new technique using existing instrumentation in an off-label and novel way to achieve better volume control and shape change in large-volume fat transplantation. As such, expansion vibration lipofilling better fits our emerging understanding of volume increase and shape change when using fat in aesthetic surgery. Presuming this technique is adopted for large-volume fat transplantation, larger case numbers are required to ultimately help define its safety. For the present time, anatomy, avoidance of vital structures, instrumentation, and technique appear to be the greatest factors in safety and efficacy.

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PATIENT CONSENT

Patient provided written consent for the use of patient's images.

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