Surgical Technique

An objective technique to calculate dermis-fat graft volume

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We describe an objective method to measure the volume of a dermis-fat graft (DFG) implant for socket reconstruction. We reviewed the charts of 10 patients undergoing dermis fat grafting as a primary or secondary implant for anophthalmic socket reconstruction between January 2018 and December 2019. The amount of the DFG required to replace the volume of an appropriate spherical implant for the operated eye was predetermined. The volume of the DFG implant was measured by the water displacement method as per the Archimedes principle. Patient demographics, complications, and the outcome were analyzed regarding cosmesis and volume replacement. All patients were satisfied with the final cosmesis. Follow-up ranged from 6 to 18 months (mean 10.7 months). Thus, we concluded that the water displacement method is a simple and easy procedure to objectively determine the amount of the autologous DFG needed to replace the volume in an anophthalmic socket.

Key words: Dermis fat graft, graft volume, measurement, water displacement method

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_130_21

Quick Response Code:

Dermis-fat grafts (DFGs) are composite, autologous grafts widely used for restoring orbital volume. They have been successfully used as primary as well as secondary orbital implants in congenital or acquired anophthalmia.[1] However, the size of the graft always has remained guesswork, unlike spherical implants, for which we have a well-established formula to calculate the exact size preoperatively.[2] We describe a simple procedure to objectively determine the volume of the DFG based on the water displacement method as described by Archimedes.[3]

This was a retrospective study approved by the institutional review board. A chart review was performed for patients undergoing DFG between January 2018 and December 2019. Written informed consent was obtained from all the study participants or their parents. The study adhered to the tenets of the Declaration of Helsinki.

All the procedures were performed by a single surgeon. Patient demographics, indications of surgery, the volume of the graft, length of follow-up, complications, and patient satisfaction with final cosmetic outcome were recorded. Any complications within the follow-up period extending to March 2020 were noted. Patients with prior history of trauma, radiotherapy, infection or scarring of the socket, and less than 6 months of follow-up were excluded. Preoperatively, all the patients underwent an A scan of the opposite eye to determine the axial length. All patients undergoing primary DFG after evisceration had an ultrasound B scan of the affected eye to rule out any intraocular mass.

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Received: 16-Jan-2021 Revision: 07-Mar-2021
Accepted: 17-Mar-2021 Published: 25-Aug-2021

For determining the size of spherical implants, the formula: axial length - 2 mm = implant diameter was followed.[2] The volume of a sphere is easily calculated using the formula $4/3\pi r3$ [Table 1]. For example, if the contralateral eye of a patient has an axial length of 20 mm, he needs a spherical implant of (20-2) 18 mm (the rest is filled by the prosthesis with a volume ~2.5 mm). An 18 mm sphere has a volume of 3 ml. Ideally, the size of DFG in this patient should equal 3 mL. However, since DFG is not spherical, there is no simple mathematical formula to calculate the same. Instead, we used the water displacement technique, as per Archimedes principle.[3]

One of the drawbacks of DFG is fat atrophy, which is less in children.[4] Hence, we added 10% extra volume in the case of children and 20% in adults to offset this outcome [Table 1].

Therefore, a child with an axial length of 20 mm in the contralateral eye would need a DFG with a volume of 3.3 mL; and an adult would need 3.6 mL of DFG.

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The procedure was performed under general anesthesia in all patients. In primary interventions, an evisceration was carried out by the "four-petal" technique, with each scleral petal attached to a rectus muscle.[5] In secondary grafts, the conjunctiva and tenon's capsule were opened with a central horizontal incision. Every effort was made to locate the extraocular muscles. The vertical and horizontal diameters of the conjunctival defect were measured. A suitable-sized DFG was harvested from the

Cite this article as: Mukherjee B. An objective technique to calculate dermis-fat graft volume. Indian J Ophthalmol 2021;69:2524-6.

Table 1: Calculation of volume of DFG

AXL of the opposite eye (in mm)	Size of spherical implant in mm (AXL -2)	Corresponding volume in mL ($4/3\pi r3$)	Volume of DFG in children in mL (+10%)	Volume of DFG in adults in mL (+20%)
16	14	1.4	1.5	1.68
17	15	1.7	1.8	2.04
18	16	2.1	2.3	2.52
19	17	2.6	2.8	3.12
20	18	3	3.3	3.60
21	19	3.6	3.9	4.32
22	20	4.2	4.6	5.04
23	21	4.8	5.2	5.76
24	22	5.6	6.1	6.72
25	23	6.4	7	7.68
26	24	7.2	7.9	8.64
28	25	8.2	9	9.84

AXL=Axial length; mL=Milliliter; and DFG=Dermis fat graft

Table 2: Demographics of the patients undergoing DFG

Pt No.	Age in years	Gender	History	Indication	Intervention	Complication	Secondary intervention	Follow-up in months
1	4	F		CCA	Primary	Nil	None	6
2	32	M	Trauma	Evisceration with implant extrusion	Secondary	Delayed epithelialization	AMT	16
3	22	M	Microphthalmia	Evisceration with implant extrusion	Secondary	Delayed epithelialization, Enophthalmos	AMT	7
4	2	M		CCA	Primary	Shallow inferior Fornix	MMG+FFS	12
5	16	F	RB	Enucleation with Implant extrusion	Secondary	Trichiasis	Electro-epilation	12
6	6	M	RB	Enucleation with implant extrusion	Secondary	Nil	None	6
7	4	F	RB	Enucleation without implant	Secondary	Nil	None	6
8	25	F	Painful blind phthisical eye	Evisceration	Primary	Nil	None	12
9	13	M	NA	Enucleation without implant	Secondary	Nil	None	12
10	3	F		CCA	Primary	Nil	None	18

DFG=Dermis fat graft; CCA=Congenital clinical anophthalmia; RB=Retinoblastoma; and NA=Not available

inferomedial quadrant of the gluteal region.[6] The height of the graft was limited by the location of the fascia overlying the glutei muscles and averaged 20 mm. An oversized graft was harvested deliberately. The donor site incision was closed in layers and an antiseptic dressing was applied.

Measurement of volume of graft: A 50 cc syringe was filled with 10 cc of saline [Fig. 1a]. The plunger was removed and the graft was placed inside the syringe [Fig. 1b]. The displacement of saline, which was equal to the volume of the graft, was measured. If the volume was more than the desired amount, fat was trimmed from the graft carefully and gradually, until the desired volume was achieved. The DFG was then placed into the orbit and the Tenon's capsule and conjunctiva were sutured to the edges of the dermis with 6/0 polyglactin (Johnson & Johnson Co., U.S.A.) continuous interlocked sutures. The scleral petals with the recti muscles in primary grafts, or when it was possible to locate the ocular muscles in secondary grafts, were sutured to the dermis as well.[6] Following surgery, the patients were reviewed after 5 days, 6 weeks, and 6 months. At each visit, the patients' sockets were checked for any infection, contraction, graft surface epithelialization, and adequacy of the volume replacement. The final cosmesis with prosthesis was noted after 6 weeks, or later, in case of any complications.

There were five males and five females, with an age ranging from 2 to 32 years (mean 12.7 years). Primary DFG was performed in four and secondary in six patients. The axial lengths of the contralateral eyes ranged from 19 to 26 mm (mean 22). The calculated volume of the DFG ranged from 3.1 to 8.6 mL (mean 4.9 mL). The final volume of DFG implanted in the patients was within 0.3 mL of the calculated amount in all, except one. In a young muscular male patient, we could harvest 7 mL of DFG instead of the requisite 8.6 mL (case #3). This patient showed mild enophthalmos postoperatively. Complications were infrequent, with two patients showing

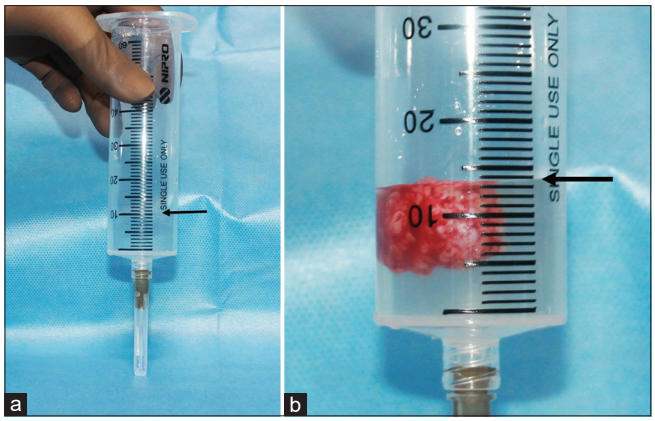

Figure 1: (a) A 50 mL disposable syringe with 10 mL saline (arrow). (b) The amount of displacement of the liquid is 3.5 mL (arrow), equal to the volume of the graft placed inside the syringe

delayed epithelialization of the surface after secondary DFG, for which amniotic membrane grafting was done after 8 weeks.[7] In these patients, the surface area of the DFG was 375 and 400 mm^2, and the graft volume was 7.5 and 7 mL, respectively. Another patient had one eyelash arising from the graft, which was removed via electro-epilation at 6 weeks, with no recurrence at her last follow-up (12 months). A 2-year-old male child with congenital clinical anophthalmia had preexisting shortening of the inferior fornix. He underwent mucus membrane grafting with fornix formation suture placement after 6 weeks. There were no complications of the donor sites. The mean follow-up was 10.7 months (range 6–18 months). All 10 patients were satisfied with their final cosmesis [Table 2].

Discussion

Autologous DFGs are an inexpensive, time-tested, and simple method to utilize in socket reconstructions, especially in the pediatric population, and after implant extrusions.[8] The fat in the DFG restores the volume of the socket, and the dermis augments the surface lining. However, the limiting factor is the inability to exactly measure the volume of the graft required. Small grafts lead to undercorrection, thereby a volume deficit, which leads to a superior sulcus deformity or an enophthalmic appearance. Large grafts run the risk of central necrosis due to compression and ischemia.[6] Unpredictable graft atrophy is seen more in patients with a history of trauma, irradiation, or infection of the socket.[8] Since atrophy is reported more in adults, we calculated the final graft volume after adding 20% in adults and 10% in children. Only one of our patients (#3) had a residual volume deficiency at the last follow-up [Fig. 2a and b]. Nevertheless, all were satisfied with the final outcome [Fig. 2c and d].

The volume of an object is measured by the amount of space occupied by that object. To date, there is no precise method to calculate or measure the volume of DFG objectively in vitro. Bullock and Brickman theoretically calculated the volume of cup-shaped DFGs using a complicated formula, V (cup) = 2/1 27πd3, in a cadaver study, as a function of diameter and depth (d).[9] As expected, this method did not attain popularity. The water displacement method, ascribed to the Greek philosopher Archimedes, is still the standard way to determine the volume of an irregularly shaped object. Instead of a syringe, any graduated

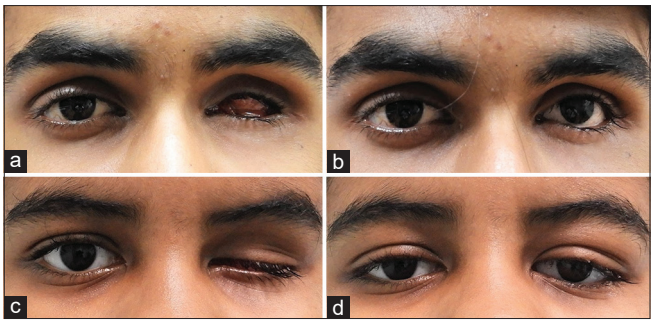

Figure 2: (a) Patient #3 after secondary DFG in situ. (b) with the customized prosthesis showing mild enophthalmos of the left eye. (c) Patient #6 after enucleation and implant extrusion. (d) After DFG and fitting of a custom-made prosthesis in the left eye

container like a glass beaker, measuring flask, or cylinder can be used. However, measuring flasks and cylinders are not large enough to accommodate the dermis fat graft. Commercially available beakers are graduated in 5 or 10 mL increments and, hence, inaccurate for our purpose. Hence, an easily available disposable 50 mL syringe can be used in these cases.

Conclusion

We conclude that the water displacement method is a quick, straightforward, inexpensive yet accurate procedure to determine the volume of the DFG.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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