Original Article

Lacrimal Gland Changes on Orbital Imaging after Glaucoma Drainage Implant Surgery

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Abstract

Purpose: This study evaluates the radiographic appearance of lacrimal gland tissue after placement of a glaucoma drainage implant (GDI) to characterize the impact of the device on the gland's imaging patterns.
Methods: We performed retrospective chart review of departmental records at two urban academic medical centers, which were systematically searched using procedure codes to identify adult glaucoma patients who underwent unilateral superotemporal GDI from January 1995 to December 2015. Radiology records were cross-checked to identify the subset of patients who underwent postoperative orbital CT or MRI. Chart review collected data on glaucoma diagnosis, management, examination findings, and clinical complaints. Imaging studies were reviewed for orbital changes using qualitative assessment of the radiographic appearances and computer-guided calculations to quantify asymmetries.
Results: A review of all eye operations in the inclusion period identified 315 patients with GDI, 13 of whom were eligible for inclusion. Elapsed time from device placement to imaging averaged 41.9 months, and the average clinical follow-up was 56.4 months. Radiographic lacrimal gland changes were appreciable in 69% (9 of 13) of patients, most commonly with posterior displacement and flattening of the gland (7 of 13). ImageJ analysis revealed significantly smaller lacrimal glands in orbits with GDI ($P = 0.04$). No clear correlation was found between gland changes and clinical dry eye symptoms.
Conclusion: GDI placement was associated with radiographically-appreciable lacrimal gland changes in two-thirds of patients, with changes occurring in a predictable pattern of lacrimal gland flattening, posteriorization, and volume loss. Radiographic changes correlated with clinical symptoms in few patients.

Keywords: Glaucoma Drainage Implants; Lacrimal Gland; Orbit

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INTRODUCTION

Advanced glaucoma treatment has trended toward increased use of glaucoma drainage implant (GDI) devices over the past 20 years. Interval data from surveys

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conducted among American Glaucoma Society (AGS) members indicate that GDI usage has increased from 17.5% of all glaucoma surgery cases in 1996 to 50.8% in 2008.[1] Placement of GDI is often the treatment of choice in patients with uveitis, iris neovascularization, prior failed filtering surgery, or other complex ocular history.[1-3] The device is most commonly positioned on the superotemporal quadrant of the eye, which places it adjacent to the lacrimal gland. The radiographic appearance of the orbital soft tissues after GDI surgery has been described in case reports or small series with limited follow-up intervals; however, to our knowledge, no study has focused on the effect of the GDI on the lacrimal gland itself.[4-10] This study was conducted to evaluate the radiographic appearance of the lacrimal gland after GDI placement.

MATERIALS AND METHODS

Institutional Review Board (IRB) approval was obtained, and the work was conducted in a HIPAA-compliant manner. The clinical and surgical records of the University of Washington Medical Center and Harborview Medical Center were searched for adult patients who had undergone placement of GDI (CPT codes 66180, 66185) between January 1995 and December 2015. This search identified 315 patients, whose records were then reviewed. Patients were excluded from the study if they had bilateral GDI, non-superotemporal position of the GDI, any history of orbital trauma, prior orbital surgery or radiation, other orbital pathology, or systemic disease affecting the lacrimal gland. The remaining records were screened to determine whether a relevant imaging study (orbital CT or MRI) was performed after GDI placement, yielding a final 13 patients for inclusion.

The images were reviewed separately by a neuroradiologist and the authors with attention to the appearance of the GDI device, lacrimal gland, and neighboring orbital soft tissue. Inter-rater agreement was assessed using the Spearman's correlation coefficient (ρ). Comparison was made to the contralateral side, enabling use of each patient's non-operative orbit as a control. In patients with multiple images, the images were reviewed for changes over time.

Quantitative assessment of lacrimal gland volume was performed using a validated method using ImageJ 1.47v software (Wayne Rasband, National Institutes of Health, Bethesda, MD, U.S.A.).[11] The software was downloaded from https://imagej.nih.gov/ij/. The scanned images were opened in the software; then, the lacrimal glands were manually outlined on each slice. The area of each selected region was multiplied by the slice thickness to calculate the volume [Figure 1c]. Outlines and calculations were repeated 3 times for each scanned image with the values averaged to improve reliability. The mean lacrimal gland volumes of the unoperated right versus left orbits were compared using a 2-sample *t*-test. For each patient, the gland volume on the operated side was compared to the non-operated (control) side with a paired *t*-test. Gland dimensions were measured tip-to-tip in axial and coronal planes as described by Tamboli et al [Figure 1a and b].[12]

Figure 1. Maxillofacial CT images of a 55-year-old patient with a history of BGI placement 5 years previously depicting lacrimal gland measurements including (a) coronal vertical length (thin double line) and width (thick single line), (b) axial length (thin double line) and width (thick single line), and (c) gland outline for volume calculation.

Retrospective chart review of all ophthalmology records was performed to collect data on demographic characteristics, surgical indications and dates, patient symptoms, topical medications, and clinical examination findings. Care was taken to screen for potential sources of orbital asymmetry not related to GDI, including unilateral topical prostaglandin analog usage. Special attention was paid to complaints related to tearing or dry eye in the clinical notes.

RESULTS

Thirteen patients (male, $n = 7$) who had undergone unilateral (right, $n = 4$) superotemporal GDI placement were included in the study. The mean age at surgery was 55.4 years (range: 18–85). The devices used were the Baerveldt glaucoma implant (BGI, 350 mm^2, $n = 4$; and 250 mm^2, $n = 3$) (Abbott Medical Optics, Abbott Park, IL), Ahmed glaucoma valve (AGV, 184 mm^2, $n = 4$) (New World Medical, Rancho Cucamonga, CA), and Molteno implant (MI, 185 mm^2, $n = 2$) (Molteno Ophthalmic, Dunedin, New Zealand). Indications for surgery included traumatic ($n = 4$), neovascular ($n = 3$), uveitic ($n = 3$), chronic angle-closure ($n = 2$), and pseudoexfoliation ($n = 1$) glaucoma. Patients with traumatic glaucoma were screened to include only patients who sustained isolated ocular injury without globe rupture or concomitant orbital injury. Clinical follow-up after GDI averaged 56.4 months (range: 1–194).

Elapsed time from device placement to imaging examination averaged 41.9 months (range: 3–147); there were 23 scans in total (orbital CT = 15 and orbital MRI = 8). Indications for imaging included facial pain ($n = 11$), orbital pain or swelling ($n = 6$), concern for orbital cellulitis ($n = 3$), unilateral vision loss ($n = 2$), and proptosis ($n = 1$). The Spearman's correlation coefficient indicated strong inter-rater reliability on recognition of lacrimal gland flattening ($\rho = 0.91$), posterior displacement ($\rho = 0.86$), fat stranding ($\rho = 0.82$), and proptosis ($\rho = 1.0$). The typical orbital imaging findings on CT and MRI are shown in Figure 2. A side-by-side comparison of a patient before versus after GDI placement is shown in Figure 3.

On quantitative assessment using ImageJ, the mean lacrimal gland volume in control orbits was 0.71 cm^3 on the right and 0.698 cm^3 on the left; there was no significant difference between the two sides ($P = 0.124$) [Table 1]. A significant difference was found between orbits with GDI (0.616 cm^3) and control orbits (0.704 cm^3) with respect to lacrimal gland volume ($P = 0.040$). Compared to those in the control orbits, the lacrimal glands in orbits with GDIs showed flattening and posteriorization, with decreased coronal width (3.8 mm with GDI compared

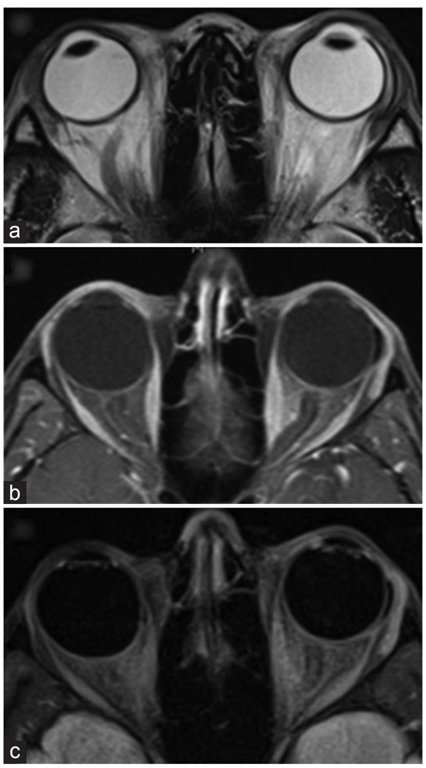

Figure 2. Typical appearance of GDI and lacrimal gland on various imaging modalities. (a) Axial T2 MRI of the brain of a 45-year-old woman with left superotemporal AGV for chronic angle-closure glaucoma (40 months after GDI). The GDI appears as a dark curvilinear structure, with bright linear signals representing bleb fluid on the deep and superficial surfaces of the device plate. The lacrimal gland is flattened and posteriorized compared to the unoperated side. (b) Axial T1 fat-saturated sequence of a 56-year-old woman with a left BGI for uveitic glaucoma (15 months after GDI). A thin bright line of the bleb fluid is collected over the dark curvilinear device plate. There are also commonly seen intermediate density soft tissue changes surrounding the GDI surface, as well as flattening and posteriorization of the lacrimal gland. (c) Same patient in B, T2 FLAIR sequence.

Table 1. Imaging findings after glaucoma drainage implant

Characteristic	Finding
Qualitative imaging findings	
+*Radiologic orbital changes*	*n*=9 patients (69%)
Lacrimal gland flattening	*n*=7 (54%)
Proptosis	*n*=1 (8%)
Quantitative imaging findings	
Mean lacrimal gland volume	
Unoperatedcontrol orbits (0.704 cm^3)	
Right control orbit	0.71 cm3
Left control orbit	0.698 cm3 (*p*=0.124, right vs left)
Orbits with GDI	0.616 cm3 (*p*=0.040, control vs GDI)
Lacrimal gland coronal width	
Unoperated control orbits	5.2 mm
Orbits with GDI	3.8 mm (*p*=0.009)
Lacrimal gland axial length	
Unoperated control orbits	14.6 mm
Orbits with GDI	15.4 mm (*p*=0.012)
Postoperative clinical complaints	
Worsened dry eye*	*n*=2 patients (15%)
New orbital symptoms (*n*=2)*	
Episodic orbital pain	*n*=1 (8%)
Intermittent binocular diplopia	*n*=1 (8%)

*All with confounding factors potentially contributing to or accounting for symptoms.

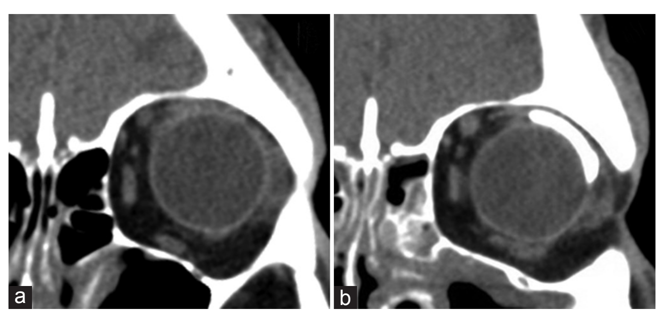

Figure 3. Coronal maxillofacial CT images of a 44-year-old man, shown side by side for comparison of the orbits before versus after GDI surgery. (a) Two years prior to GDI placement. (b) Same patient, 1 month after surgery, showing a localized fluid collection laterally and displacement of the lacrimal gland tissue.

to 5.2 mm without; $P = 0.009$) and increased axial length (15.4 mm with GDI compared to 14.6 mm without; $P = 0.012$). There was no significant change in the lacrimal gland volume in relation to elapsed time since GDI placement ($P = 0.48$) when comparing subgroups of patients who were imaged 0–4 months, 5–8 months, 9–12 months, and >1 year after surgery; however, the subgroups were small ($n = 2$, 1, 0, and 10 patients). There was a trend toward lower gland volumes in patients with 350-mm^2 BGI compared to those with AGV or MI ($P = 0.084$).

Review of clinical documentation revealed that 15% ($n = 2$) of patients in the series noted a change in dry eye symptoms after GDI surgery. However, each patient had confounding factors, including the addition of a new glaucoma medication in one, and bilateral dry eye sensation after unilateral surgery in the other. New orbital symptoms were noted after GDI surgery in 15% ($n = 2$) of patients, with one patient experiencing intermittent binocular diplopia that resolved 3 months postoperatively; the other patient reported episodic superotemporal orbital pain. Although imaging and clinical examinations were unrevealing in this patient, she underwent explantation of her GDI and the symptoms resolved.

DISCUSSION

GDI placement for management of glaucoma is increasingly prevalent, with the most common position of the device being in the superotemporal orbit, near the lacrimal gland. A better understanding is needed of how this placement affects the gland, including its radiographic appearance.

Of the 3 most common GDI types, BGI devices are radiopaque on CT and plain films due to impregnation with barium, whereas MI and AGV are made up of radiolucent silicone or polypropylene.[6,7,10] On MRI, all 3 devices appear as a curvilinear low-intensity signal at the shunt endplate on T1- and T2-weighted images, with an associated fluid bleb that is isointense to the vitreous. In our series and others, it has been common to see the bleb fluid along both the superficial and deep face of the plate when successful filtering is occurring.[10] It is also normal to find a linear structure with soft tissue density, which likely corresponds to the Tenon's encapsulating the GDI and bleb. On CT images, the lacrimal gland tissue is hyper-dense when compared to the Tenon's capsule, which is, in turn, more radio-dense than the bleb fluid. On MRI, the gland tissue is typically isointense to the extraocular muscle, and muscle and gland both enhance with gadolinium more than the neighboring soft tissues.

Lacrimal gland dimensions and volumes in normal adults have been previously evaluated using CT and MRI modalities. In general, most studies have found no significant difference in gland dimensions between genders or between the left and right orbits; and there is a linear decrease in the gland volume with age.[12-15] Although the scanned images in this study were retrospectively reviewed, which entails some limitations due to variability in patient position or image rotation, our measurements in the unoperated orbits found dimensions and volumes that are similar to the previously reported values.[12-15] However, lacrimal glands in orbits with GDI were found to have significantly smaller volume, narrower coronal width, and longer axial length, suggesting that presence of the superotemporal GDI promotes flattening and shrinkage of the gland. The trend toward smaller gland volumes in orbits with larger GDIs in our series suggests the gland changes are due to mass effect; however, gland atrophy may also play a role. A prospective study to perform and evaluate orbital imaging after GDI at standard postoperative time points would be helpful to determine whether this flattening and shrinkage represents gland compression versus gland atrophy, or both.

Our study found no appreciable relationship between lacrimal gland size and dry eye related clinical complaints in patients after GDI placement. The study has several limitations that may have influenced the results, including its retrospective nature, different time lapses between surgery and imaging, small sample size, and lack of objective data on patient tear production. It is also possible that the effect of the lacrimal gland size on tearing and ocular surface disease is disguised by the larger impact of topical glaucoma therapy in this patient population.[16] A study specifically evaluating lacrimal gland volume in relation to quantitatively measured tear output, controlled for topical medications, would be of use in the future.

In conclusion, radiographically appreciable lacrimal gland changes are seen in approximately two-thirds of patients after GDI placement, but these changes can be clinically asymptomatic. Conversely, orbital symptoms ostensibly related to the GDI can occur without notable imaging abnormalities. Common changes are lacrimal gland volume loss, flattening, and posterior displacement of the gland. Developing a better understanding of these changes allows for a more meaningful interpretation of the imaging findings when patients with GDIs present with postoperative orbital complaints. Further prospective work is needed to elucidate the clinical impact of these radiographically appreciable gland changes.

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Conflicts of Interest

There are no conflicts of interest.

REFERENCES

1. Lee J, Sun N, Zhao X, Kang Q, Chen L, Fan X. Practice preferences for glaucoma surgery: A survey of the American Glaucoma Society in 2008. *Ophth Surg Lasers Imaging* 2011;42:202-208.
2. Gedde SJ, Singh K, Schiffman JC, Feuer WJ; Tube Versus Trabeculectomy Study Group. The tube versus trabeculectomy study: Interpretation of results and application to clinical practice. *Curr Opin Ophthalmol* 2012;23:118-126.
3. Joshi AB, Parrish RK, Feuer WF. 2002 Survey of the American Glaucoma Society: Practice preferences for glaucoma surgery and antifibrotic use. *J Glaucoma* 2005;14:172-174.
4. Jeon TY, Kim JH, Kim ST, Chung TY, Kee C. MR imaging features of giant reservoir formation in the orbit: An unusual complication of Ahmed glaucoma valve implantation. *Am J Neuroradiol* 2007;28:1565-1566.
5. Marcet MM, Woog JJ, Bellows AR, Mandeville JT, Maltzman JS, Khan J. Orbital complications after aqueous drainage device procedures. *Ophthal Plast Reconstr Surg* 2005;21:67-69.
6. Ceballos EM, Parrish RK. Plain film imaging of Baerveldt glaucoma drainage implants. *Am J Neuroradiol* 2002;23:935-937.
7. Detorakis ET, Maris T, Papadaki E, Tsilimbaris MK, Karantanas AH, Pallikaris IG. Evaluation of the position and function of aqueous drainage implants with magnetic resonance imaging. *J Glaucoma* 2009;18:453-459.
8. Reiter M, Schwope R, Walker K, Suhr A. Imaging of glaucoma drainage devices. *J Computer Assist Tomogr* 2012;36:277-279.
9. Reiter MJ, Schwope RB, Kini JA, York GE, Suhr AW. Postoperative imaging of the orbital contents. *Radiographics* 2015;35:221-234.
10. Sano I, Tanito M, Uchida K, Katsube T, Kitagaki H, Ohira A. Assessment of filtration bleb and endplate positioning using magnetic resonance imaging in eyes implanted with long-tube glaucoma drainage devices. *PLoS One* 2015;10:e0144595.
11. Dello S, van Dam RM, Slangen J, van de Poll MC, Bemelmans MH, Greve JW, et al. Liver volumetry plug and play: Do it yourself with ImageJ. *World J Surg* 2007;31:2215-2221.
12. Tamboli DA, Harris MA, Hogg JP, Realini T, Sivak-Callcott JA. Computed tomography dimensions of the lacrimal gland in normal Caucasian orbits. *Ophthal Plast Reconstr Surg* 2011;27:453-456.
13. Bingham CM, Castro A, Realini T, Nguyen J, Hogg JP, Sivak-Callcott JA. Calculated CT volumes of lacrimal glands in normal Caucasian orbits. *Ophthal Plast Reconstr Surg* 2013;29:157-159.
14. Lee JS, Lee H, Kim JW, Chang M, Park M, Baek S. Computed tomographic dimensions of the lacrimal gland in healthy orbits. *J Craniofac Surg* 2013;24:712-715.
15. Bukhari AA, Basheer NA, Joharjy HI. Age, gender, and interracial variability of normal lacrimal gland volume using MRI. *Ophthal Plast Reconstr Surg* 2014;30:388-391.
16. Mathews PM, Ramulu PY, Friedman DS, Utine CA, Akpek EK. Evaluation of ocular surface disease in patients with glaucoma. *Ophthalmology* 2013;120:2241-2248.