

Multimodal ocular imaging in diagnosis and management of occupational ocular argyrosis

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Abstract:

Occupational ocular argyrosis is a rare disorder associated with accumulation of silver in the eye due to its occupational exposure. A 39-year-old male patient, a silver utensils polisher for the past 30 years, presented with bilateral gradual diminution of vision (presently 20/200) for 2 years. His serum silver levels were raised and ocular examination revealed bilateral greenish brown corneal deposits and complicated cataract. Anterior segment optical coherence tomography (OCT) and confocal microscopy suggested deposition of silver in various corneal layers. Multifocal electroretinogram showed a generalized decrease in sensitivity of P1 waves. Increased internal aberrations on aberrometric profile favoured phacoemulsification followed by intraocular lens implantation in both eyes. Postoperatively, the visual gain of 20/20 and normal fundus picture on indirect ophthalmoscopy, macular OCT, and fundus autofluorescence favored good prognosis in both eyes.

Keywords:

Ocular argyrosis, multimodal ocular imaging, occupational

INTRODUCTION

Occupational ocular argyrosis (OA) is a rare disorder associated with long-term deposition of silver in the eye due to its occupational exposure.^[1-4] The diagnosis of OA is mainly established by characteristic history and presentation. Various invasive investigations such as serum silver levels and conjunctival biopsy have been described in the literature for its diagnosis. While these methods directly determine the presence of silver in the human body, their negative results do not refute the diagnosis of OA. Recently, numerous ocular imaging methods favoring an indirect presence of silver particles in ocular structures and subsequent functional effects have also been described.

At present, we report a case of occupational OA in a young male presenting primarily with a complicated cataract. We also discuss the role of multimodal ocular imaging in its diagnosis and management (handling preoperative challenges), and in predicting prognosis. In addition, the postoperative results of phacoemulsification with posterior chamber intraocular lens implantation in this condition are also reported.

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CASE REPORT

A 35-year-old male presented to us with a chief complaint of gradually progressive diminution of vision (DOV) in both eyes for 2 years. The patient was a silver utensils polisher by occupation for the past 30 years and polished the utensils at a workbench of 30–40 cm for 8 h/day. His best-corrected visual acuity was 20/200 in both eyes and the near vision was N-10 in the right eye and N-8 in the left eye. Slit-lamp examination revealed bluish-gray pigmentation of the conjunctiva, greenish-brown deposits at the level of Bowman's membrane (BM), posterior stroma and Descemet's membrane (DM) [Figures 1 and 2], nuclear sclerosis grade 2 with posterior subcapsular cataract (with polychromatic luster), and intraocular pressure of 10 mmHg in both eyes. Bilateral fundus examination was limited by media haze. Systemic examination revealed distinctive slate-gray pigmentation of the forehead, periorbital skin, eyelids, nose, cheeks, and upper extremities, violaceous pigmentation of buccal mucosa, and elevated serum silver levels (50 µg/L as measured by atomic absorption spectrometry, normal range <0.1 µg/L) and increased melanin

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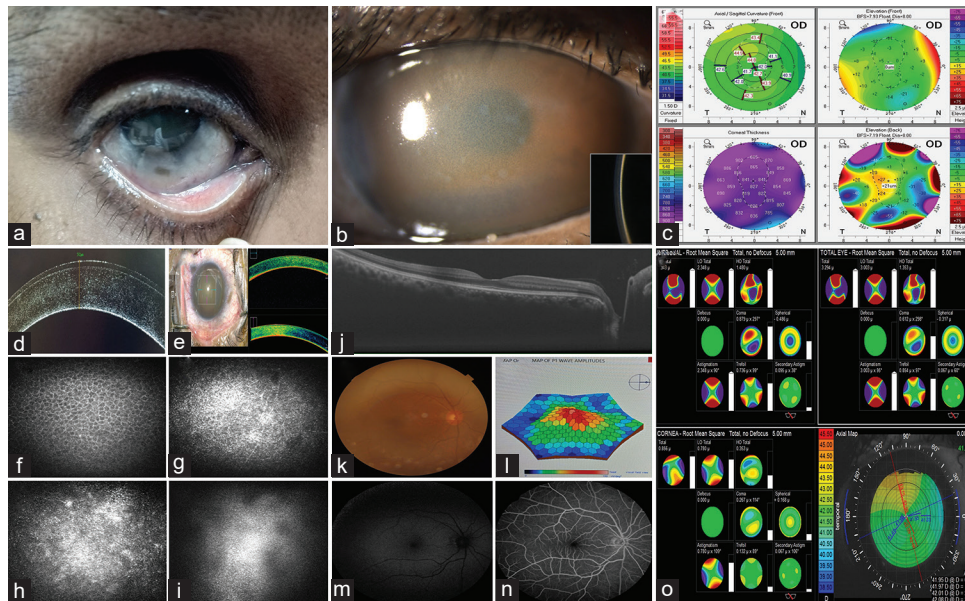


Figure 1: Right eye; slate-gray pigmentation of conjunctiva (a); greenish-brown deposits in DM (b); hyperreflective areas on Pentacam (c); hyperreflective DM on ASOCT (d) and i-OCT (e); normal epithelium, hyperreflective dots in anterior to mid-stroma obscuring visualization of endothelium on HRT-3 (h-i); normal macular OCT and fundus (j-k); generalized decrease in sensitivity of P1-wave with loss of foveal peak on mf-ERG (l); normal blue FAF (m); mild late leak from disc and perifoveal areas on FFA (n); increased internal aberrations (o)

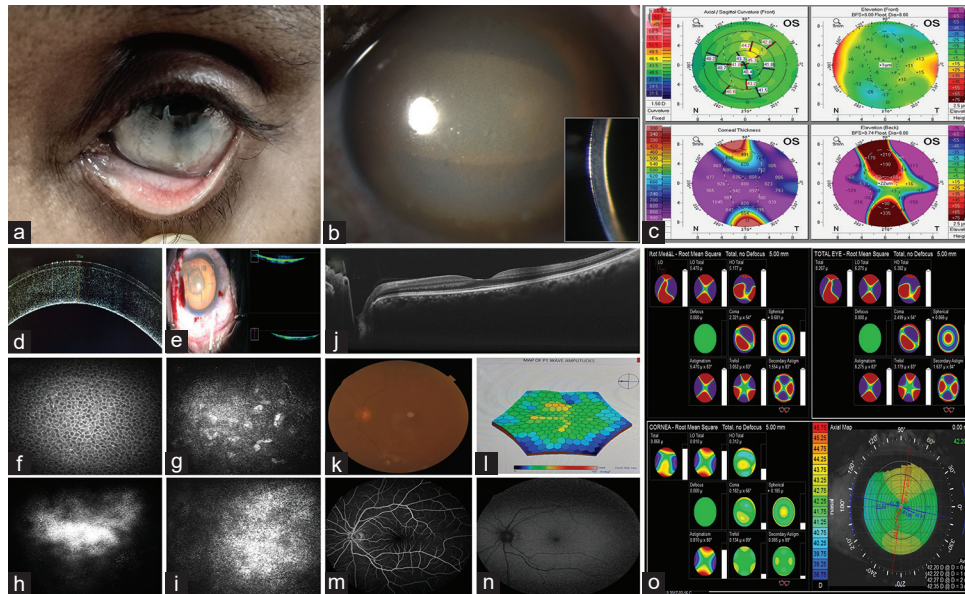


Figure 2: Left eye; slate-gray pigmentation of conjunctiva (a); greenish-brown deposits in DM (b); hyperreflective areas on Pentacam (c); hyperreflective DM on ASOCT (d); PSC as seen on i-OCT (e); normal epithelium, hyperreflective dots in anterior to mid-stroma obscuring visualization of endothelium on HRT-3 (j-i); normal macular OCT and fundus (j-k); generalized decrease in sensitivity of P1-wave with loss of foveal peak on mf-ERG (l); normal blue FAF (m); mild late leak from disc and perifoveal areas on FFA (n); increased internal aberrations (o)

pigment deposits on skin biopsy.^[5,6] Various differential diagnoses of similar deposits in the cornea include gold, copper, and iron deposits; corneal blood staining; and drug deposits. Diagnosis of OA was confirmed by a characteristic occupational history, bilateral presentation of signs and symptoms, absence of ocular trauma or chronic drug use, characteristic ocular and dermatological findings, and elevated serum silver levels.

Anterior segment optical coherence tomography (OCT) (ASOCT, RTvue 1000, Optovue, USA) revealed hyperreflective BM and DM. Corneal confocal microscopy (CCM, HRT-3, Heidelberg Engineering Inc., USA) demonstrated scattered hyperreflective dots (suggestive of bright silver precipitates) in anterior to mid-stroma that obscured visualization of the endothelium [Figures 1 and 2]. Scheimpflug imaging (Pentacam, Oculus, USA) seemed unreliable with hyperreflective

areas corroborating with superficial deposition of silver. iTrace (Hoya iTrace™, Japan) revealed increased total eye aberrations majorly contributed by internal aberrations. Laser interferometry (LI) and visually evoked responses (VER) were suggestive of good visual potential in both eyes. Multifocal electroretinogram (mf-ERG) revealed a generalized decrease in sensitivity of P1 wave (P1 is first positive wave derived from the inner retina, predominantly Muller cells and bipolar cells) with loss of foveal peak (right eye > left eye).

After obtaining informed consent, bilateral sequential (right eye followed by left eye) phacoemulsification (Centurion® vision system, Alcon, USA) followed by in-the-bag IOL (Acrysof® IQ, Alcon, USA) implantation was undertaken. Tests for the stability of ocular surface, immersion B-scan, autokeratometry, videokeratography (Atlas, Zeiss, Germany), and optical biometry were assessed preoperatively. The IOL power [Table 1] was calculated using Lenstar (LS 900, Haag Streit, USA). At the beginning of the surgery, intraoperative OCT (i-OCT)-guided visualization of corneal layers revealed hyperreflective DM and posterior capsule of lens corroborating with preoperative clinical findings and investigations. The integrity of posterior capsule and stability of IOL could also be determined on i-OCT. Cataract surgery was uneventful in both eyes with a postoperative uncorrected distance visual acuity of 20/20 and near vision of N-6 (with + 3D refractive correction). The posterior segment appeared normal on indirect ophthalmoscopy, macular OCT, and fundus autofluorescence (FAF) [Figures 1 and 2]. Fundus fluorescein angiography (FFA) demonstrated mild leaks from the optic disc and perifoveal areas in late phases. At 6-month follow-up, status quo was maintained. The patient was advised to use appropriate protective bodywear and goggles, or consider changing his occupation for halting further ocular and systemic damage due to silver accumulation.

DISCUSSION

OA is a rare disorder associated with the deposition of silver in various parts of the eyeball such as eyelids, tears,

conjunctiva, lacrimal sac, cornea, lens, ciliary body, and Bruch’s membrane [Table 2].^[1-4,7-10] These deposits can be either asymptomatic or lead to cosmetically disturbing skin discoloration, and nyctalopia (from photoreceptor dysfunction). Rarely, DOV from corneal involvement or senile cataract can also occur. However, to the best of our knowledge, the primary presentation of OA with complicated cataract and comprehensive multimodal ocular imaging for its surgical planning is being described for the first time.

Imaging modalities such as ASOCT and CCM predicted an indirect presence of silver granules in the anterior segment, particularly the cornea. Besides, another consistent finding in all these investigations was a poor structural assessment of corneal endothelium despite its good functional status. To the best of our knowledge, aberrometry changes in these eyes are being reported for the first time. This modality not only demonstrated the untoward functional effect of silver deposits on the aberrometric profile but also guided cataract extraction in our case. As direct visualization of the posterior segment was difficult in the preoperative phase due to media haze, LI, VER, and mf-ERG allowed appropriate preoperative prognostication of the disease. Besides, minimal changes in these investigations also favored occupational modifications for halting further disease progression.

The reliability of optical biometry in OA has not been determined to date, thereby making IOL power calculation tough in such cases. To establish the accuracy of IOL power in our case, we compared data from both optical and ultrasonic biometry. The results of Scheimpflug imaging were refuted as these may be erroneous due to blockage of both short and long wavelengths of light by silver deposits.^[1] However, this requires further studies as no such limitation was noticed with other imaging modalities. Monofocal IOL was implanted in our patient and we recommend the same till long-term results of premium IOLs are determined in these eyes. During surgery, i-OCT-assisted visualization of the anterior segment demonstrated findings similar to preoperative ASOCT. It also provided information on the integrity of the posterior capsule and stability of intraocular lens, thereby guiding a smooth

Table 1: Ocular surface and biometric details of our patient

Parameter	Right eye	Left eye
TBUT	12 s	13 s
Schirmer test	12 mm at 5 min	18 mm at 5 min
Laser interferometry	6/12	6/12
Visually evoked response	8.5 µV/100 ms	8.8 µV/102 ms
Videokeratography	41.6D/43.20D at 12°/102°	41.42D/42.94D at 164°/74°
Keratometry (A)	41.75D/42.75 at 20°/110°	41.5D/42.5D at 165°/75°
Axial length (i)	24.34 mm	24.85 mm
Axial length (L)	24.40 mm	24.86 mm
Keratometry (L)	41.87D/42.88D at 19°/109°	41.51D/42.61D at 168°/78°
Anterior chamber depth (L)	4.07 mm	4.18 mm
White to white diameter (L)	12.53 mm	12.29 mm
IOL power (L)	+19.5D	+19D

**IOL power was calculated using SRK/T formula. TBUT: Tear film break up time, A: Autokeratometer, i: Immersion B-scan ultrasonography, L: Lenstar, IOL: Intraocular lens

Table 2: Review of case reports on ocular argyrosis

Author	Source of silver	Ocular structures affected	Conjunctival biopsy	Corneal confocal microscopy	Posterior segment investigations
Stafeeva <i>et al.</i> ^[1]	Drinking water from well purified with silver nitrate	Facial skin, periorbital area, forearms, fingernails, normal cornea, RPE changes and drusen at macula	-	-	FFA: Dark choroid in later phases FAF: No hyper/hypo AF Macular OCT: Multiple excrescences of RPE ERG: Normal
Palamar <i>et al.</i> ^[2]	Silver worker	Peri-ocular skin, ocular surface and cornea	Squamous metaplasia at epithelium, extracellular silver particles in substantia propria	Corneal epithelium normal, highly reflective punctiform deposits from anterior to mid stroma and increasing through corneal endothelium. EC CNA	-
Madi <i>et al.</i> ^[3]	Silver generator used for purifying water	Face, neck, upper limbs, eye lid skin, and conjunctiva	-	-	Macular OCT: Hyperreflective RPE-BM complex without clearly identifiable choroid or capillaries FFA: Dark choroid and retinal ischemia with areas of capillary dropout FAF: Normal ff-ERG and EOG: Normal
Sánchez-Pulgarín <i>et al.</i> ^[4]	Silver jeweler	Conjunctiva, fornix and caruncles and cornea	Presence of silver deposits	Well-defined, highly reflective dots throughout out stroma and large hyperreflective plaques at DM and BM. No changes in epithelium or endothelium	-
Wu <i>et al.</i> ^[8]	Conjunctival cautery with silver nitrate stick	Cornea	-	Normal epithelium, diffuse highly reflective deposits in BM, anterior stroma, deep stroma, decreased number of nerves in deep stroma, hyperreflective plaque at DM, EC CNA	-
Sarnat-Kucharczyk <i>et al.</i> ^[9]	Industrial silver salts	Neck, upper limbs, eyelid skin and conjunctiva, cornea, drusenoid deposits in macular region	-	Confluent small silver deposits, DM thickening, with numerous punctate hyperreflective silver deposits, EC CNA	Macular OCT: Drusenoid changes in RPE, increased ganglion cells complex thickness PVEP: P100 latencies delayed mf-ERG: Reduced amplitudes of P1 wave p-ERG: Markedly abnormal with delayed implicit time and reduced amplitudes of P50 and N95 ff-ERG: Decrease amplitudes and implicit times of a and b waves, low amplitude of oscillatory potentials EOG: Normal
Gallardo <i>et al.</i> ^[10]	Lash and brow tint	Eyelids, caruncle, conjunctiva, and cornea	Silver deposition in the BsM and substantia propria	-	-
Sánchez-Huerta <i>et al.</i> [*]	Art silver solderer	Cornea	-	Highly reflective deposits in granular pattern anterior to corneal endothelium	-
Zografos <i>et al.</i> ⁵	Laboratory technician	Eyelid, conjunctiva, lacrimal caruncle and cornea	Small, blackish granules in stroma, no inflammation	-	-

Contd...

Table 2: Contd...

Author	Source of silver	Ocular structures affected	Conjunctival biopsy	Corneal confocal microscopy	Posterior segment investigations
Pala <i>et al.</i> [#]	Silver craftsman	Conjunctiva and cornea	Normal epithelium with dark granular pigment in submucosa	Highly reflective material with granular pattern anterior to endothelium. EC CNA	-
Dudeja <i>et al.</i> [*]	Silversmith	Conjunctiva, cornea and lens	-	-	Mac OCT, FFA, 30-2 HVF: Normal
He <i>et al.</i> ^{§,#}	Photographic film manufacturer	Conjunctiva, caruncle, cornea, and pterygium	-	-	Mac OCT: Normal
Our case	Polisher of Silver utensils	Eyelids, conjunctiva, cornea	Negative	Scattered hyperreflective dots in anterior to mid-stroma, EC CNA	Scheimpflug imaging: Unreliable with hyperreflective areas Aberrometry: Significant internal aberrations Mac OCT, FAF: Normal FFA: Mild leak from disc and perifoveal areas in late phases mf-ERG: Generalized decrease in sensitivity of P1 wave with loss of foveal peak

[#]BsM. BsM: Basement membrane, RPE: Retinal pigment epithelium, AF: Autofluorescence, EC CNA: Endothelial cell could not be assessed, BM: Bowman's membrane, DM: Descemet's membrane, FFA: Fundus fluorescein angiography, FAF: Fundus AF, OCT: Optical coherence tomography, ERG: Electroretinogram, PVEP: Pattern visually evoked potential, mf-ERG: Multifocal ERG, ff-ERG: Full-field ERG, p-ERG: Pattern ERG, EOG: Electrooculogram, RPE-BM: RPE-Bruch's membrane complex, HVF: Humphrey visual field analysis. Superscripted number after every author represents the reference number as cited in text. Extra references. *Sánchez-Huerta V, De Wit-Carter G, Hernández-Quintela E, Naranjo-Tackman R. Occupational corneal argyrosis in art silver solderers. *Cornea* 2003;22:604-11. [§]Zografos L, Uffer S, Chamot L. Unilateral conjunctival-corneal argyrosis simulating conjunctival melanoma. *Arch Ophthalmol* 2003;121:1483-7. [#]Pala G, Fronterré A, Scafa F, Scelsi M, Ceccuzzi R, Gentile E, *et al.* Ocular argyrosis in a silver craftsman. *J Occup Health* 2008;50:521-4. Dudeja L, Dudeja I, Janakiraman A, Babu M. Ocular argyrosis: A case with silver deposits in cornea and lens. *Indian J Ophthalmol* 2019;67:267-8. ^{§,#}He X, Simmons NL, Wozniak RAF. Anterior Segment Optical Coherence Tomography in Ocular Argyrosis. *Cornea*. 2020 Nov;39(11):1433-1435.

surgery. A good refractive outcome of phacoemulsification followed by IOL implantation in our case favors the safety of this surgery in similar eyes. Even though the surgery was uneventful in our case, little is known about the presence of silver in aqueous fluid, the release of silver particles from corneal tissue during surgical maneuvers, and the immediate reaction of these dispersed silver particles with titanium present in the phacoemulsification probe. The long-term effect of silver on residual cortical material, IOL, and the posterior capsule also warrants further evaluation. In addition, our case report is anecdotal and limited by the exclusion of contrast sensitivity in the assessment of visual function.

With increasing awareness, changes in the therapeutic application of silver, progress of preventive industrial medicine, and improvement in working practices, the incidence of argyria is expected to decrease in future. As the amount of silver deposited is directly proportional to the duration of employment and there is no known effective treatment for OA, our patient was advised either change of occupation or use of protective bodywear to limit further exposure and subsequent silver induced toxicity to various internal organs.^[7,9]

To conclude, multimodal ocular imaging can aid in better management of OA and should be employed whenever possible.

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Conflicts of interest

There are no conflicts of interest.

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