

## Original Research Article

# Preferred characterization of orbital infection (cellulitis) with exposure dose and relative medication

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### ABSTRACT

**Background:** A retrospective study presenting the endemic orbital infection (cellulitis) that breakout during dusty storm season; aiming to ascertain and showing the precedence of MRI for diagnosis of orbital infection rather than CT and revealing the diagnostic abilities of cross-sectional matrices spectrum.

**Methods:** Based on retrospective collection of diagnostics (CT and MRI) information for randomly selected patients with cellulitis and the targeting the relevant data (image interpretation, exposure dose (DLP and CTDI<sub>vol</sub>), age, BMI and matrix cross-section spectrum findings).

**Results:** The exposure dose of orbital CT exam was 59.4 (mGy) as CT dose index (CTDI<sub>vol</sub>) and 917.3 (mGy/cm) as dose length product (DLP) that increase by increment of age and BMI. The obese patients only exposed to dose exceeding the National Diagnostic Reference by 2.8%. MRI confirmed the inflammation around the optic nerve and extension to postero-inferior portion of the globe and affecting the optic nerve with left sided proptosis (0.5cm) better than CT. The cross-sectional matrix successfully revealed that: the Lt optic nerve's gray value (density) increases by a factor of 17.7 (a u) and enlarged by 5 pixels greater than the Rt optic nerve. Thickening, rough surface increased gray value by 30.5 (a u), muco-thickening and choncheal enlargement at the medial boarder of Lt orbit as 10.0 pixel and Lt eye ball enlarged by a factor of 10.9 pixels.

**Conclusions:** MRI wisely diagnose orbital infection with more details and overcoming patient radiation exposure and usage of image spectrum gives detailed characterization of lesion morphology.

**Keywords:** Cellulitis, CT-Exposure, Orbital, Spectrometry

### INTRODUCTION

The orbital region is considered as one of the frequent inflammables site due to direct exposure to inflammatory factors. The inflammatory factors could imply microparticles or nanoparticles dust, viral infection, bacterial infection such as *Hemophilus influenzae* (*H. influenzae*), *Staphylococcus aureus* and *Streptococcus* species; or could be due to recent illness or trauma, such as orbital fractures and intra-orbital foreign bodies.<sup>1</sup> These factors may lead to orbital cellulitis which is a

serious infection and inflammation of the soft tissues of the orbit posterior to the orbital septum with obvious distinguished presentation as presence of eye proptosis in combination with a congested eye and inflamed eyelid. Orbital cellulitis has serious and even fatal consequences such as: vision loss, cavernous sinus thrombosis, meningitis, brain abscess, osteomyelitis of the orbital bones, and septicemia.<sup>2</sup> It has been a cause of death for 17% and 20% loss of vision during 1940s, however such percentages dropped to 1-2.5% as mortality and 3-11% for loss of vision due to successive technique of diagnosis

and treatment recently; while in case of intracranial and or cavernous sinus invasion the morbidity and mortality still high i.e. 10-20%.<sup>3,4</sup> And globally orbital cellulitis is considered as a disease of children among the age group up to 15 years old which is ascribed to underdeveloped immune system, with underproduction of IgGs in infants between the ages 1 and 5 years.

The dusty season in Saudi Arabia (April-May, 2018) in Qassim state has presented considerable number of patients complaining of eye inflammation (Buraidah Central Hospital and King Fahad Specialized Hospital). The common symptoms and signs encountered among the patients were: eye swelling/redness, severe pain, edema of the eyelids, conjunctiva, limited ocular movements with or without vision blurring which is accordance with different inflammatory process as cellulitis.<sup>5</sup>

The classification of orbital cellulitis implies five groups based on Chandler et al, group 'I' consists of patients with edema confined to the eyelids only.<sup>6</sup> Group 'II' represents true orbital cellulitis, manifested by edema of the eyelids, diffuse orbital edema, vision changes, and painful eye movements. Group 'III' characterized by the presence of a subperiosteal abscess (SPA), which is marked by accumulation of pus between the periosteum and the orbital bones. Group 'IV' is distinguished by the presence of a true orbital abscess, which causes more severe proptosis and ophthalmoplegia. Group 'V' is the end stage of orbital cellulitis with extension of the infection into the CNS, causing cavernous venous thrombosis.<sup>3,7</sup>

The CT and MRI imaging have major role to characterize orbital cellulitis and even (SPA); and as well orbital ultrasound has better sensitivity to abscess but fail to resolve orbital apex, visualize sinuses and intracranial tissues; hence physicians only recommend to use CT as routine for such cases; although medical physicists prefer MRI for avoidance of radiation dose exposure.<sup>8,9</sup> Therefore the aim of this study is to ascertain and showing the precedence of MRI as a diagnostic tool for orbital infection rather than CT which is accompanied by considerable radiation exposure to patient; despite the expensiveness of MRI in addition to show the diagnostic abilities of cross-sectional matrices spectrum based on comparison.

However, the clinical presentation for the current case (male, 42 years) were: left eye blur of vision, eye redness, mild pain, diplopia on looking up, restricted eye movement, limited up and down gazing, proptosis (Figure 1). And based on the clinical investigations; the patient given eye drop (Ciprocin and Oculac) administrated three times per day. However, this treatment leads to further blur of vision, and excessive tears and proptosis. Therefore, the patient has been referred for further urgent investigations (CT and MRI).



**Figure 1: The patient presentation during the infection days; depicting the redness and widening protruded and widen left eye ball.**

## METHODS

The current study has been carried out during the period extends from: March 1-July 30, 2018 as a retrospective and randomly collected variables and data related to seventy patients (70) who only developed orbital infection and referred for both CT and MRI (contrast) examinations. The exclusive parameters imply non-infectious cases, cases out of dusty storm season and totally blindness.

Preclinical presentations of patients were: decrease vision, redness, diplopia, eye lid edema and restricted eye movement. The clinical investigations have been done at optometry clinics revealed that: mild optic nerve congestion, mild venous tortuosity, proptosis with clear lens, and vitreous. Also, Rt eye (20/20), Lt eye (20/70), intra ocular pressure (IOP) 19/20, and the color vision was Rt eye (OD = oculus Dexter) 15/15, Lt eye (OS = oculus sinister) 2/15. Then accordingly the patients have been referred for further medical examination with conclusion (Lt eye proptosis with limiting up gazing, optic neuropathy, and idiopathic orbital inflammation)

The equipment used were multi-slice CT scanners (MSCT) 64 slice (*Toshiba Sensation Aquilion 64*) and MRI system version was Siemens Avanto 2010, strength 1.5 Tesla closed MRI machine with super conductive coil.

Patient exams by CT and MRI have been done in Supine position and after 6 hours fasting and assessment of renal function depending on laboratory test for creatinine level.

The collected data were the age (10-60 years old, with average of 42 years old), body mass index (BMI), pathology diagnosis (*Cellulitis*), CT dose index per volume (CTDI<sub>vol</sub>) and dose length product (DLP) from the display CT console.

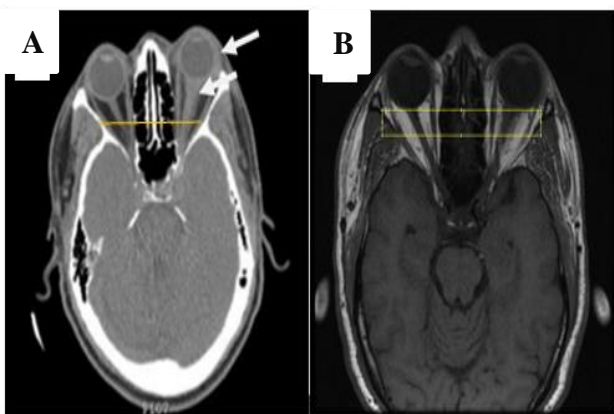
Magnetic Resonance Images with contrast media findings were collected to be compared with CT findings. The CT and MRI matrices spectrums (conversion of analogue

image to digital spectrum) were obtained from the relevant images using a software JAVA SE RUNTIME ENVIRONMENT (JRE) VERSION 6. The extracted spectrum for both eyes ball at the level of optic nerve and the region of optic nerves as relation between pixel distance (width of anatomical site) and gray value of CT (absorption) has been plotted in graphic spectrum together with relevant image segment.

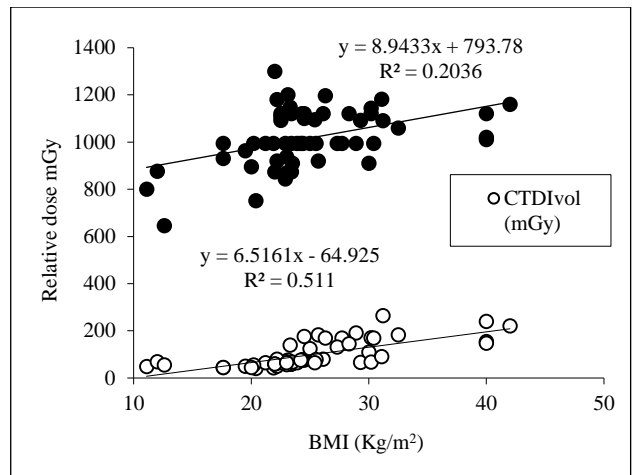
**RESULTS**

The following results illustrate selective images related to orbital cellulitis that being diagnosed by CT and MRI as in Figure 2A and 2B respectively (the arrows show the appearance of inflammation effect on the optic nerve and the thickening of sclera of the eye ball. The yellow line in Figure 2A depict the level of interest that have been selected and converted to digital spectrum presented in Figure 5 (CT digital spectrum). Figure 3 illustrating the correlation between the body mass index versus patient exposure dose per volume and per length due to CT exam; while and Figure 4 shows the correlation between patient ages versus patient exposure dose per volume and per length due to CT exam that obviously revealed the increment of patients' exposure dose following the increment of the two parameters (BMI and age).

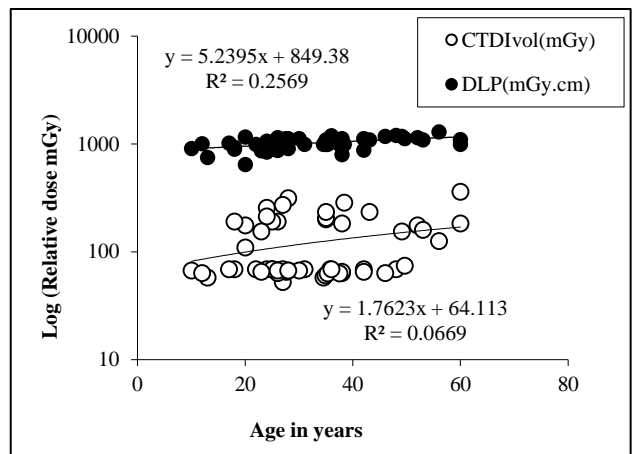
Figure 5 presenting the correlation between Gray value (radiation absorption coefficient) versus the tissue thickness or distance in pixel (mm) as a matrix cross section spectrum extracted from CT image Figure (2A) for Rt and Lt eyes at the level of optic nerves. Figure 6: shows the same correlation as in Figure 5; but has been derived from eyes globe zone highlighted in Figure 7 (CT image). The program used to convert the analogue images to digital spectrum was software JAVA SE RUNTIME ENVIRONMENT (JRE) version 6.



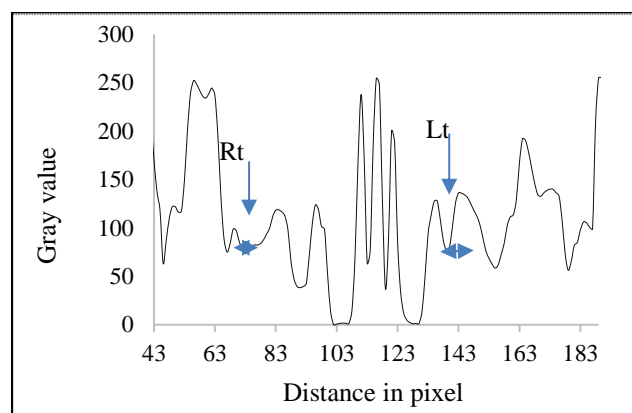
**Figure 2: CT image. (A) For brain and orbit depicts soft tissue density seen at inferio-lateral aspect of left orbit arrowed. And MRI (B) showed a mild inflammatory process affecting the left orbit mainly around the optic nerve fat planes extending to the postero-inferior portion of the globe.**



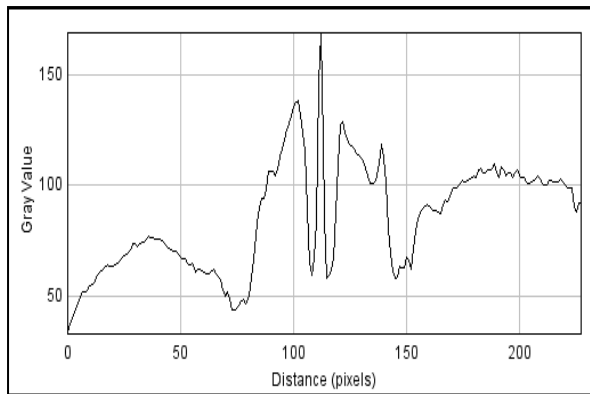
**Figure 3: Correlation between the BMI and the relative CTDIvol (mGy) and DLP (mGy/cm) for the randomly selected sample preceding CT for orbital and brain image.**



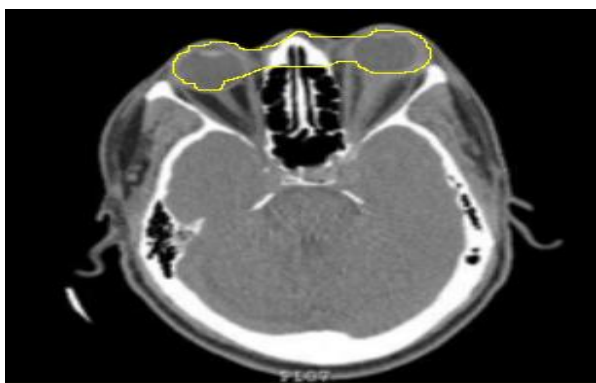
**Figure 4: Correlation between the age and the relative CTDIvol (mGy) and DLP (mGy/cm) for the randomly selected sample preceding CT for orbital and brain image.**



**Figure 5: A matrix cross section spectrum extracted from CT image Figure (2-a) yellowed rectangular; for Rt and Lt eyes at the level of optic nerves.**



**Figure 6: A matrix cross section spectrum converted from analog CT image (Figure 7) for Rt and Lt eyes at level of both eye balls**



**Figure 7: The CT image with relevant zone of the eye globe from which the matrix cross section spectrum.**

## DISCUSSION

The CT image (Figure 2A) revealed an evidence of soft tissue density seen at inferio-lateral aspect of left orbit, extraconal sparing the recti muscles with evidence of minimal external protrusion of the globe and increasing density around the eye globe (arrowed) (May 1, 2018). Such exam exposed the patient to 59.4 (mGy) as  $CTDI_{vol}$  and 917.3 (mGy/cm) as dose length product (DLP) which would induce even little radiation risks, despite some scholars like to use CT imaging conventionally in emergency section in hospitals.<sup>10-12</sup> Such exposure dose could be overcome by using MRI as medical physicists' preference. The amount of exposure dose has been increases following BMI (Figure 3) and aging (Figure 4); the increment of  $CTDI_{vol}$  and DLP depending on aging and BMI ascribed to the factors dependent such as the scattered radiation and the required system output and also the DLP (mGy/cm) appeared greater than the  $CTDI_{vol}$  (mGy). Same result has been obtained by Boos et al, in which they deduced that: the  $CTDI_{vol}$  for the obese (30-35Kg) and extremely obese (>35Kg) has exceeded the National Diagnostic Reference (NDR) stated by Australian Radiation Protection and Nuclear Safety Agency, depending on obesity characterization (BMI).<sup>13,14</sup> Also, Francis et al, they showed that both

$CTDI$  and DLP doses were increased as the BMI increases and the anteroposterior diameter increment.<sup>15</sup>

From the randomly selected cases underwent CT exam for orbit and brain; only the obese patients have exceeded the exposure dose stated by National Diagnostic Reference by 2.8%. Same increment of exposure dose has been observed depending on aging which is due to increment of absorption coefficient of patient body structure. In the field of radiology and depending on ALARA principle; the staff have to seek for and obtaining a diagnosable image rather than an optimum quality image; and a little of image noise would be acceptable since the relevant diagnostic enquires could be answered in order to reduce patient exposure dose.<sup>16</sup> However, the context of "ALARA" recently considered as induction for radiophobia leading some patients to avoid specified diagnostic system which in turn leading to miss diagnosis or obtaining blurred image with less resolution to pathological evidence; based on argument and opinion stated by Jeffry et al.<sup>16</sup>

While MRI (Figure 2B) showed a mild inflammatory process affecting the left orbit mainly around the optic nerve fat planes extending to the postero-inferior portion of the globe without cavitation, there is post contrast enhancement, the optic nerve is also affected and resulted in bi-vision in up and lateral gazing. Minimal left sided proptosis (0.5cm) was noted (May 3, 2018) also; there was successful response to treatment (prednisolone) in resolving eye protrusion (MRI done after CT images and medication by 3 days). These findings truly reflect the characteristics of inflammatory process of the orbit (cellulitis) that response successfully to the treatment course consist of corticosteroid (prednisolone tablets 20mg) as systemic antibiotic therapy that reducing and diminishing the signs such as sinus swelling, stenosis, hastening the resolution of edema, preventing elevation of orbital pressure and compression of orbital structures and furthermore, they inhibit fibroblast proliferation, allowing for reduced scarring case operated.<sup>17</sup>

The matrix cross section spectrum extracted from CT image (Figure 2A) for Rt and Lt eyes at the level of optic nerves (Figure 5) showed that: the Lt optic nerve's gray value (density) increases by a factor of 17.7 (au) and enlarged by 5 pixels greater than the Rt optic nerve which is causing the eye protrusion and distortion of vision. And from the matrix spectrum at the level of Rt and Lt eyes balls (Figure 6) which derived from (Figure 7) and based on comparison with Rt eye; the left eye appeared thick rough surface with a gray value approaching 117.8 (au) relative to the Rt eye which has a gray value of 87.3 (au) indicating the blurring of vision, protrusion and increased density of the eye ball by a factor of 30.5 gray value. Also, there is a muco-thickening and choncheal enlargement at the medial boarder of Lt orbit as 10.0 pixel relative to 9.0 pixels for the Rt orbit and as well the Lt eye ball has been enlarged and showed 43.9 pixels (width) while the Rt eye ball width measured 33.0 pixels



(width) i.e. the Lt eye ball enlarged by a factor of 10.9 pixels; which is ascribed to striking by inflammation.

## CONCLUSION

The study recommends and prefers MRI as diagnostics tool for orbital infection generally and for orbital cellulitis specifically to avoid patient's exposure to radiation. The usage of image matrices spectrum with enhancement of relevant program or equipment (Nuclear Magnetic Spectroscopy) would be more helpful for more characterization of lesion and adjacent tissues.

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