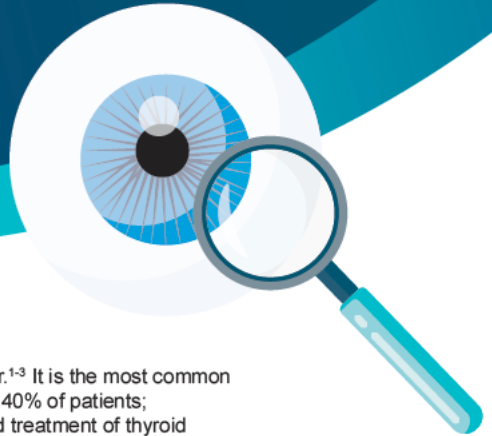


Orbital Imaging in Thyroid Eye Disease (TED)



Background

TED is a lifelong, debilitating, progressive autoimmune disorder.¹⁻³ It is the most common extrathyroidal manifestation of Graves' disease, affecting up to 40% of patients; however, these conditions are pathophysiologically distinct, and treatment of thyroid function does not improve TED.^{1,4-8}

TED is characterized by extensive remodeling of the orbital soft tissues, including inflammation/edema and expansion of the extraocular muscles and retrobulbar fat.^{1,9} Common signs and symptoms of TED include eyelid retraction, diplopia, pain, dry eye, eyelid swelling, conjunctival chemosis, photophobia, and proptosis.^{2,3} These manifestations may progress to complications such as ulceration, exposure keratopathy, and dysthyroid optic neuropathy.^{1,10}

TED is a heterogeneous and underdiagnosed disease.¹¹ Patients with TED can experience years of symptoms, symptomatic treatments, and office visits before receiving a diagnosis.¹¹⁻¹³ Additionally, bilateral orbital involvement is found on imaging in 50-75% of patients with TED, even if the clinical manifestations are unilateral or asymmetric.¹⁴ Although common clinical indices like clinical activity score (CAS), Bahn-Gorman scale, and proptosis measurements capture some aspects of the disease, they may not be reliable indicators for retrobulbar inflammation or orbital soft tissue enlargement.^{15,16} Diagnostic methods such as computed tomography (CT) and magnetic resonance imaging (MRI) can evaluate extraocular muscle and orbital fat enlargement, as well as inflammation/edema including findings suggestive of dysthyroid optic neuropathy, and thus aid in TED diagnosis and disease management.¹⁶



Mechanism of Disease

Insulin-like growth factor-1 receptor (IGF-1R) overexpression on the cell surface of orbital fibroblasts is a key component of TED pathophysiology.¹ IGF-1R and thyroid-stimulating hormone receptor (TSHR) are co-localized and form a signaling complex.^{1,17} Autoantibody activation of the complex triggers T cells, B cells, and fibroblasts to elicit the inflammatory responses observed in TED. This signaling complex activation leads to severe inflammation and expansion of tissue, muscle, and fat cells behind the eye, leading to an increased production of inflammatory cytokines, hyaluronan, and extracellular matrix proteins.^{1,18}

The role of imaging in TED^{15,16,19}



Establish diagnosis demonstrating characteristic fusiform enlargement of the extraocular muscles with sparing at the tendinous junction



Assess orbital soft tissues including the extraocular muscles and orbital fat for inflammation/ edema and enlargement



Evaluate for optic nerve compression secondary to extraocular muscle and/or orbital fat enlargement



Monitor response to therapy



Conduct preoperative assessment for anatomic visualization especially before an orbital decompression

Imaging findings in TED^{15,16,19}

- Enlargement and inflammation/edema of the extraocular muscles
- Enlargement and inflammation/edema of the orbital fat
- Expansion/remodeling of the orbital bony cavity
- Proptosis
- Lacrimal gland enlargement/inflammation
- Signs of dysthyroid optic neuropathy particularly at the orbital apex



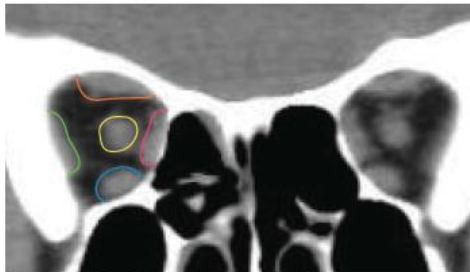
Relative strengths and limitations of CT and MRI for imaging in TED¹⁹

	CT	MRI
Bony architecture	+++	+
Volume/size of orbital soft tissues (muscles/fat)	+++	+++
Inflammation/edema within orbital soft tissues (muscles/fat)	+	+++
Proptosis	+++	+++
Dysthyroid optic neuropathy	++	+++
Monitor response to treatment	++	+++
Cost	+++	++
Radiation (lens is among the most radiosensitive organs)	-	+++

Advantage (+) and disadvantage (-) of the main imaging modalities in TED

Adapted from reference 19

Normal:
Coronal non-contrast CT



Case courtesy of Dalia Ibrahim, Radiopaedia.org, rID: 44049

orange=superior rectus muscle
green=lateral rectus muscle
blue=inferior rectus muscle
pink=medial rectus muscle
yellow=optic nerve

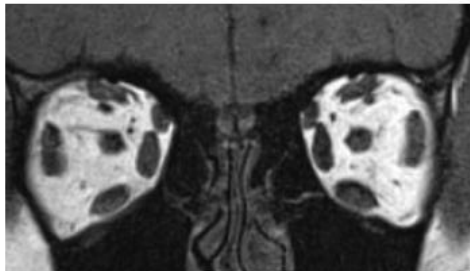
TED:
Coronal non-contrast CT



Case courtesy of Ian Bickle, Radiopaedia.org, rID: 48392

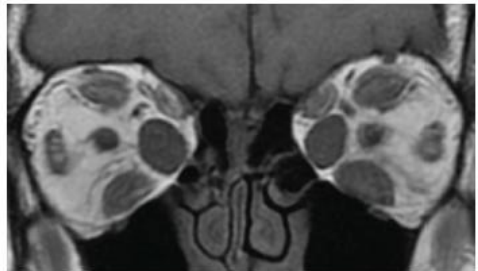
Bilateral enlargement of the inferior, medial, superior, and lateral rectus muscles

Normal:
Coronal MRI T1-weighted sequence



Case courtesy of Ian Bickle, Radiopaedia.org, rID: 52509

TED:
Coronal MRI T1-weighted sequence



Case courtesy of Ian Bickle, Radiopaedia.org, rID: 85413

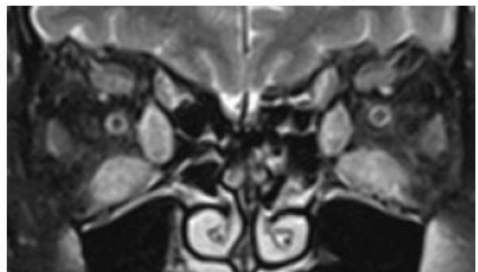
Bilateral enlargement of the inferior, medial, superior, and lateral rectus muscles

Normal:
Coronal MRI short tau inversion recovery (STIR)-weighted sequence



Case courtesy of Ian Bickle, Radiopaedia.org, rID: 52509

TED:
Coronal MRI STIR-weighted sequence

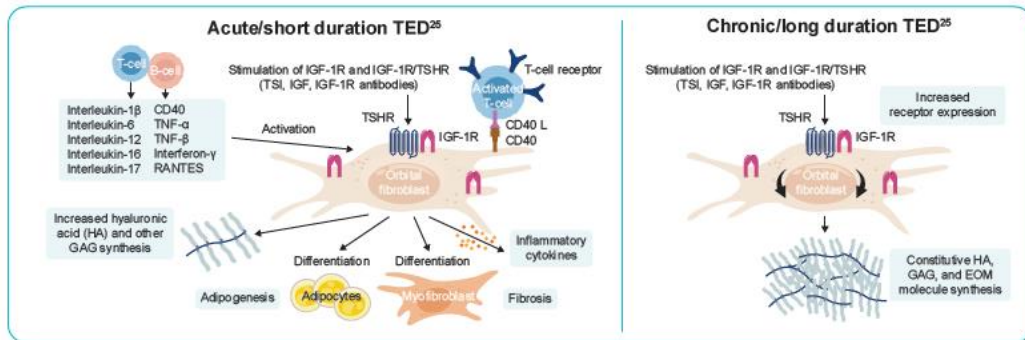


Case courtesy of Qutailba Jafar Mahmoud, Radiopaedia.org, rID: 167879

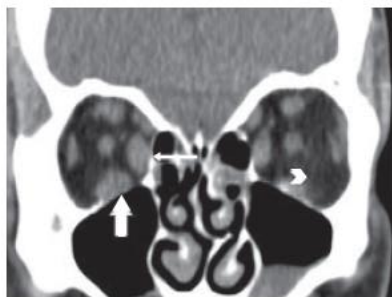
Bilateral enlargement and inflammation/edema of the inferior, superior, and medial rectus muscles as well as inflammation/edema of the orbital fat

Orbital soft tissue remodeling regardless of disease duration or activity

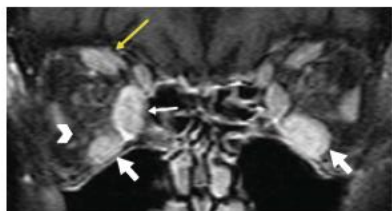
TED is a heterogenous disease.¹¹ Regardless of disease duration, however, IGF-1R overexpression persists along with sustained orbital soft tissue expansion.^{25,26}



CT imaging and MRI of short duration, patients with high CAS²⁸



Coronal non-contrast CT: Enlarged inferior rectus (thick white arrow) and medial rectus (thin white arrow) and inflammation of orbital fat (white arrowhead)



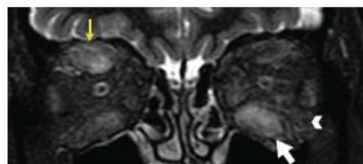
Coronal STIR MRI: Enlargement and inflammation/edema of the inferior rectus (thick white arrow), medial rectus (thin white arrow), and superior rectus (thin yellow arrow) as well as inflammation/edema of the orbital fat (white arrowhead)

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CT imaging and MRI of long duration, patients with low CAS^{25,27}



Coronal non-contrast CT: Asymmetric enlargement of the extraocular muscles bilaterally. There is crowding of the left optic nerve suggestive of dysthyroid optic neuropathy.



Coronal STIR MRI: Enlargement and inflammation/edema of the inferior rectus (thick white arrow) and superior rectus (yellow arrow) and inflammation/edema of the orbital fat (white arrowhead)



Coronal STIR MRI: Minimal enlargement and inflammation/edema of the inferior rectus (thick white arrow) and superior rectus (thin yellow arrow)

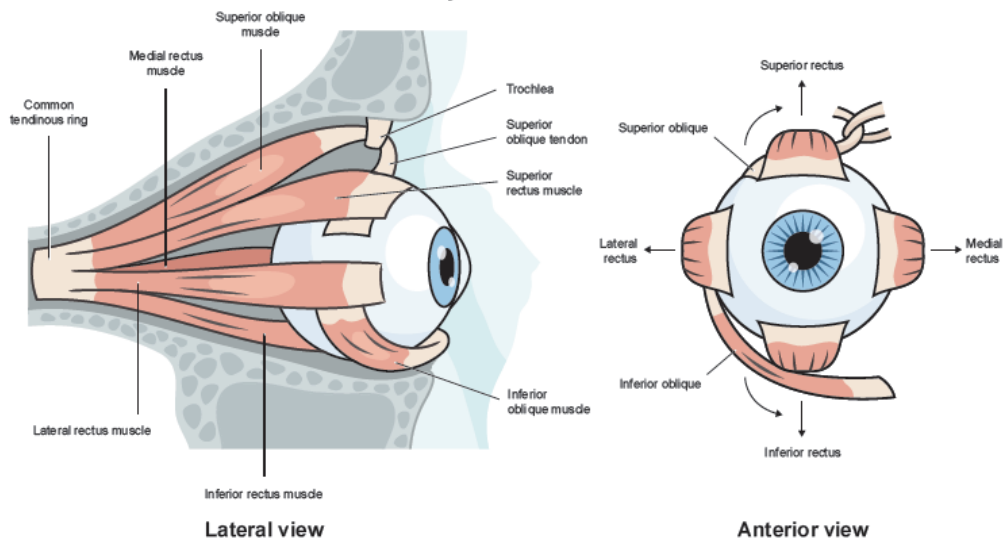


Key Takeaways

- TED is a progressive, lifelong autoimmune disease leading to soft tissue remodeling of the orbital muscles and fat, including enlargement and inflammation/edema.^{1-3, 9}
- Bilateral orbital involvement is seen in approximately 50-75% of patients with TED, even if the clinical manifestations are unilateral or asymmetric.¹⁴
- Imaging findings of orbital soft tissue enlargement and inflammation/edema may be present regardless of disease duration or activity.^{15,19}
- Imaging such as CT and MRI can be a helpful adjunct tool for diagnosing TED, assessing disease severity (including dysthyroid optic neuropathy), and monitoring response to therapy.^{15,16,19}



Eye muscles



Adapted from Reference 28

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