Abstract

The mechanisms of diplopia occurrence involve the impairment of factors related to optical anatomy, neurological pathways, muscle contraction and position and volume of the orbital content. Although ophthalmologists encounter double vision most often in their practice, this sign is at the crossroad with other medical specialties, such as neurology, maxillofacial surgery and ENT. The purpose of the present review is to systematize the existing information and to enhance the understanding of diplopia-related facts, from the perspective of maxillofacial surgery. Aspects related to clinical examination and imaging are discussed together with an overview of the main causes of diplopia in the context of head and neck disorders. Key factors that should alert the surgeon as to the possible presence of severe conditions, or for emergency surgery, are underlined.

Keywords: diplopia, orbit, exophthalmos, tumour.

1. INTRODUCTION

The presence of diplopia may complicate patient’s life, due to the difficulty of performing every-day tasks, such as reading, walking, driving or practising skilful jobs [1]. Frustration due to the inability to cope with daily activities may affect social interactions and ultimately decrease the psychosocial integration as well as patient’s life quality.

Diplopia can be a presenting sign of ophthalmologic, neurologic, maxillofacial or ENT conditions, but it can also have an iatrogenic cause, following either local anaesthesia or surgery of the eye, orbit and sinuses, as well as neurosurgical procedures. Maxillofacial surgeons frequently encounter diplopia as an associating sign in traumatic, oncologic or reconstructive procedures, and it is therefore important to differentiate between different types of double vision and to be familiar with the main mechanisms of their occurrence, the main treatment options as well as with the situations that indicate the need for emergency surgery for protecting the visual function. Whichever the context of diplopia, a proper diagnosis of the underlying cause always involves an additional ophthalmologic evaluation.

2. TYPES OF DIPLOPIA

Clues towards the aetiology of double vision are provided by establishing whether it is perceived only when both eyes are open (binocular diplopia), or whether the double image is also maintained when the patient covers one eye (monocular diplopia). The monocular type is not commonly related to severe conditions. A frequent causal finding is the presence of dry eye associated lesions, or some structural defects of the eye [2]. Therefore, monocular diplopia is managed by the ophthalmologist. During practice in maxillofacial surgery, we usually encounter a binocular diplopia determined by ocular misalignment. In opposition to the monocular type, binocular diplopia should always trigger further investigations in order to exclude possible serious neurological or neoplastic conditions [3]. Establishing the type of diplopia (Table 1) is performed during ophthalmologic examination, which provides important information on its possible aetiology.
Table 1. Main types of diplopia [3]

<table>
<thead>
<tr>
<th>MAIN TYPES OF DIPLOPIA</th>
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<tr>
<td>Binocular</td>
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<td>Vertical</td>
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<tr>
<td>Horizontal</td>
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<tr>
<td>Torsional</td>
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3. COMMON CAUSES OF DIPLOPIA IN MAXILLOFACIAL SURGERY

3.1. LOCAL ANAESTHESIA

Transient diplopia may occur after performing truncular anaesthesia for dental or maxillofacial procedures. The most common cause is the infiltration of the infraorbital nerve at the infraorbital foramen. A correct technique implies deposition of the anaesthetic inside the canal, by entering it with the tip of the needle for a distance of 5 mm. Pressure during infiltration, or incorrect estimation of needle depth inside the foramen may facilitate the entrance of anaesthetic substance inside the orbit, affecting extraocular muscles and therefore leading to double vision.

Direct diffusion of the anaesthetic is also incriminated in superior posterior alveolar nerve blocks, due to superior injection with deposition of the anaesthetic in the pterygo-maxillary fissure towards the pterygo-maxillary fossa. Other incriminated mechanisms, such as intra-arterial or intravenous injection, may be responsible for the rarely reported cases of ocular complications, including diplopia, following inferior alveolar nerve blockage [4-6].

Diplopia caused by anaesthetic techniques is usually transitory and it resolves within 6 hours after the procedure, although permanent complications have been described in literature. Other ocular complications mentioned in relation to nerve blocks are amaurosis, ophthalmoplegia, mydriasis and palpebral ptosis [6].

Local anaesthesia for eyelid or orbital surgery may also lead to double vision, due to toxicity of the substance used, to intravascular injection, vascular injury with hematoma formation or injury of other orbital structures.

3.2. TRAUMA

Blow-out fractures of the orbital floor can associate diplopia in several scenarios, indicating the need for surgical treatment and the degree of emergency in performing surgery. The most commonly encountered situation is the inferior displacement of the orbital content towards the maxillary sinus, which results in different eye level and consecutive double vision. Surgical reconstruction of the orbital floor is thus indicated for restoring orbital volume and for ensuring disappearance of diplopia. Double vision may initially be masked due to the initial post-traumatic oedema of the orbital structures, being manifested only a couple of days after presentation, when the initial tumefaction is resolved. In this case, an isolated fracture of the orbital floor can go unnoticed by the clinician in the absence of adequate imaging. A three-dimensional CT reconstruction helps identifying the degree of orbital content displacement, the presence of soft tissue entrapment, and improves overall understanding of the fracture pattern in view of the surgical treatment [7].

Another situation is the so-called “trap-door” fracture, when the inferior rectus muscle becomes entangled between the fracture fragments and results in diplopia, accompanied by restriction in the superior movement of the eye. This scenario represents an indication for emergency surgery in order to release the inferior rectus muscle and reconstruct the orbital floor. In children, the thick elastic periosteum, that can remain integer even in the presence of a fracture, causes additional pressure on the entrapped muscle, possibly leading to irreversible changes regarding eye movement and diplopia. Diplopia and sometimes restricted eye movement could be the only presenting signs in pure blow-out fractures, in the absence of other post-traumatic lesions, especially in the case of children [8] or elderly that may omit the history of trauma.

Diplopia is also associated with the presence of intraorbital hematomas and emphysema. In such cases, double vision is commonly associated with exophthalmos and should indicate the need for orbital computed tomography in order to
rule out the presence of a retrobulbar hematoma. In such a case, compression to the optic nerve could determine permanent injury and blindness. Therefore, surgery must be performed to drain the hematoma within 2 hours from the onset.

Not all fractures of the inferior orbital wall associated with diplopia have indication for surgery [9]. In some cases, the injury and oedema of extrinsic muscles of the eye can also result in double vision, the treatment being therefore conservatory. Non-compressive orbital hematomas that do not interest the retrobulbar space can also be treated by conservatory means, just like orbital emphysema.

The presence of post-traumatic orbital foreign bodies is also associated with diplopia, due to orbital volume change, mechanical limitation due to muscle entrapment, but also as a cause of injury to orbital structures. Surgery for removal of the foreign body must be performed in emergency, to avoid complications and sequelae [10].

Although most cases of diplopia involving trauma are traced from the presentation of the patient, we should not underestimate the postoperative occurrence or maintenance of diplopia. Failure to adequately reconstruct the orbital floor can result in persistent postoperative diplopia. The development of retrobulbar hematoma following orbital surgery is a feared complication. Post-operative accentuation of diplopia and of associated visual disturbances can announce the development of a retrobulbar hematoma and indicate emergency drainage surgery.

Permanent diplopia can be the result of untreated fractures of the zygomatic-maxillary complex and orbit, due to initial contraindication and recommendation for delayed treatment. Healing in malposition is frequent in this location, due to rapid consolidation, in approximately two weeks. Sequelae involving diplopia and enophthalmos can also occur as a result of initially undiagnosed blow-out fractures. Corrective surgery is much more difficult due to fibrous changes of the orbital content and distorted anatomy [11]. The main purpose is restoring the adequate orbital frame and volume for achieving a proper eye position and for the disappearance of double vision [12].

3.3. BASEDOW DISEASE

In cases of Basedow disease, patients can present with either monocular or binocular diplopia. The monocular double vision is mostly due to the dry eye, commonly associated with exophthalmos and lid retraction, as the main characteristics of thyroid orbitopathy [2,13]. It usually resolves with proper ophthalmologic treatment after removal of the cause by performing orbital decompression surgery.

The cause of binocular diplopia related to Basedow disease is the unequal level of the eyes, due to the presence of either unilateral exophthalmos or bilateral unsymmetrical exophthalmos, or of associated restrictive myopathy [14]. Orbital decompression surgery has the role of restoring the aesthetic appearance of the patient, but mostly to restore functionality, by resolving double vision, compressive optic neuropathy, and the lesions associated with exophthalmos and dry eye [15]. Additional surgery for lengthening of the superior eyelid is also necessary in cases demonstrating severe retraction for the resolution of dry eye-related symptoms.

Double vision can also follow orbital decompression procedures. The incidence is variable, depending on the technique used, either addressing the orbital fat, or decompression involving the walls of the orbit, and even considering the approach used - transpalpebral versus endoscopic approach. The unilateral or bilateral character of the procedure also plays a role with more frequent encounters of post-procedural double vision following bilateral decompression surgery [16]. Additionally, it is difficult to assess the impact of the degree of preoperative diplopia on the postoperative result. Few studies report results mentioning separately the possible scenarios - the initial post-operative onset of double vision, the complete resolution of diplopia after surgery, partial resolution of diplopia, or accentuation of the existing preoperative diplopia. Nevertheless, diplopia following decompression surgery can be transient and resolve within 2 weeks to 3 months after the procedure. It is thought that the main cause is inflammation, due to surgical injury to orbital structures and associated
myositis that gradually resolves in time. Permanent post-operative diplopia is caused by the displacement of the orbital content inferiorly and medially, associated with modifications of the bony walls, surgical disinsertion of the inferior oblique and increased tension on the superior oblique muscle [14]. Diplopia due to muscle imbalances may be improved in certain cases by the off-label use of botulinum toxin [17] or strabismus surgery. Surgical attempts for improving post-operative diplopia should be performed at least 6 months after decompression surgery [16].

3.4. EYELID SURGERY

Any surgery surrounding the orbit can be associated with complications such as diplopia, including plastic surgery procedures - especially inferior eyelid blepharoplasty [11]. Such mechanisms involve local anaesthetic-related lesions, such as myotoxicity, or injury of orbital blood vessels with occurrence of intraorbital haematomas, injury of the extraocular muscles, or even fibrosis formation and restriction of movement [18,19]. Injury of the extraocular muscles occurs most often during manipulation, relocation, excision or excessive cauterisation of the orbital fat [14]. Although rare, diplopia following plastic surgery procedures may lead to legal concerns.

3.5. ORBITAL TUMOURS

Space occupying lesions of the orbit displace the orbital content, leading to exophthalmos and associated binocular double vision, due to the unequal level of the eyes. In developing stages, when proptosis is not yet obvious, diplopia might be the only complaint of patients. Therefore, proper investigations in the presence of binocular double vision could help an early diagnosis of tumour pathology [20]. Restoring functionality following surgery for orbital tumours is important for the social reintegration of patients. Procedures for malignant tumour resection, depending on location and extension, may involve the “en bloc” removal of the orbital floor together with the tumour. This is especially the case for maxillary sinus carcinoma extended to the orbital floor. The resulting defects cause an inferior positioning of the orbital content and, therefore, the occurrence of diplopia. The simultaneous reconstruction of the orbital floor is possible by the use of titanium mesh, bone grafts, regional or distant composite flaps. Still, most surgeons prefer to perform the reconstruction following at least 1 year from the initial surgery in order to perform an easy direct check of possible tumour recurrences and to avoid complications associated with post-operative radiotherapy. During this time, an obturator can be used for closing of the oro-nasal communication, but also for restoring the position of the orbital content by providing support [21]. In opposition to malignant tumour treatments, in patients with benign tumours we aim at restoring functionality during the same procedure by performing orbital floor reconstruction. A common example is mucocele of the maxillary sinus or of the fronto-ethmoidal sinuses that can grow to erode through the inferior or medial orbital walls and cause proptosis and double vision [22]. Reconstructive procedures aim at restoring the level of the orbital floor for adequate support of the orbital content and disappearance of diplopia. Titanium mesh allows the reconstruction of the lost bone surfaces and contours, and it could be associated with bone grafts, where it is considered necessary. Other options include the use of composite regional flaps like the temporo-parietal osteo-fascial flap [22,23].

3.6. DRY EYE RELATED DISORDERS

SJOGREN

Sjogren disease is often associated with the enlargement of the major salivary glands, in particular parotidomegaly, which is mostly bilateral. This change in facial appearance, together with diminution of saliva flow and related disorders, determine patients to present to the maxillofacial department. Other patients might be referred to the OMF surgeon from the rheumatology, dermatology or ophthalmology departments for performing minor salivary gland biopsy that contributes to the diagnosis of Sjogren disease as one of the 3 major diagnostic criteria. One of the additional complaints of patients at presentation might be the presence of diplopia. The decrease of lacrimal secretion is the incriminated factor, since it causes lesions of the
cornea that may be associated with monocular double vision. Schirmer’s test is used to quantify the amount of lacrimal secretion. The corneal lesions are monitored by the ophthalmologist, who also conducts the treatment considering the degree of lacrimal secretion diminution.

Management of monocular diplopia in Sjogren disease usually involves addressing the cause by supplementing with artificial tears and offering corneal protection, in addition to topical anti-inflammatory drugs and systemic secretagogues. Certain drugs may accentuate dry-eye related symptoms and diplopia - e.g. tricyclic antidepressants or diuretics [2]. The associated conditions and medication should be carefully assessed and, whenever possible, medications causing a supplementary decrease in lacrimal secretion should be replaced, or administered in reduced doses.

In Sjogren patients, diplopia should not be underestimated. Differentiating between monocular and binocular double vision in such cases is important, since Sjogren disease is strongly associated with lymphoma, [24] that could present as an orbital mass causing different degrees of proptosis and diplopia, together with dry eye disease [25].

**ECTROPION**

Monocular double vision is a common complaint among patients with ectropion of different aetiologies, since its presence signifies inadequate moistening of the eye due to inadequate containment of tears, but also to the incomplete eyelid closure during sleep, which accentuates drying of the eye.

Post-operative ectropion can be the result of any surgery involving inferior eyelid incisions whether it regards plastic surgery procedures, trauma reconstructive procedures or oncologic surgery. The subciliary incision, frequently performed in blepharoplasty, as well as procedures for zygoma and orbital floor fracture repair, are the most commonly mentioned ones, when it comes to cicatricial ectropion occurrence [26]. Although cosmetic appearance is a common reason for complaint, the functional aspect related to dry eye-associated lesions, diplopia included, can be even more bothersome for the patients. Scar ectropion can be addressed by several surgical techniques, but many authors consider structural fat grafting to be most fulfilling in returning the suppleness and flexibility of tissues, as well as in providing support for the inferior eyelid [27-29].

Mechanical ectropion is a frequent complication of procedures involving the removal of medium- and large-sized tumours of the middle and superior genian region, as well as of the inferior palpebral region. The plasty of such defects requires the use of flaps that cause different degrees of pull on the inferior eyelid and lead to the occurrence of ectropion, associated dry eye-related lesions and monocular diplopia. The use of suspension sutures anchored to the periosteum or to fascial structures - like the temporo-parietal fascia - causes lifting of tissues and minimizes the traction on the inferior eyelid, therefore decreasing the degree of ectropion and minimizing the functional disturbances, including diplopia. A minimally invasive method to obtain the same soft tissue support and lift is by the use of barbed threads insertion through an incisionless procedure [30].

The paralytic ectropion and lagophthalmy due to facial nerve paralysis can be addressed by the already mentioned technique of static suspension for inferior eyelid support and decreased traction, but additional procedures, such as inferior eyelid shortening and gold plate insertion at the level of the superior eyelid, may also be necessary for improved functional results [31].

**OTHER CAUSES**

Since diplopia is a common finding in neurologic and ophthalmologic conditions both at presentation and as a post-operative complication, it is important to exclude causes of diplopia that may be unrelated to the coexisting maxillofacial disorder. An ophthalmologic evaluation should be performed in all cases of double vision, even if the determining cause seems obvious. A neurologic examination may also be necessary when the presence of additional neurological signs could alert the clinician towards a more serious disorder, or for excluding a neurological condition when no other cause was determined [32]. Additionally, double vision due to a maxillofacial disorder can be concomitantly manifesting with an
ophthalmologic cause of diplopia, which might explain treatment unresponsiveness when only one is addressed.

Ophthalmologic conditions such as pre-existing amblyopia or myopia may accentuate the level of discomfort of the patient and complicate diplopia treatment [33]. Ophthalmologic management should focus on the most advanced methods for achieving best results, especially when amblyopia is diagnosed in an adult in association with double vision. In contradiction with the classical view stating that amblyopia cannot be treated in adults, the results of a study developed in Iasi, Romania, for strabismic and anisometropic amblyopia, showed that treatment with Levodopa stimulates brain plasticity and may eventually allow improvement of visual acuity in adults, as well [34].

Other causes of diplopia should be carefully excluded by ophthalmologic examination, since advanced treatment methods can be employed for each ophthalmologic condition associated with diplopia, leading to favourable outcomes upon life quality. Strabismus can be found also in myopic eyes [35]. For selected cases, orthokeratology can be used, which reduces myopia by flattening the cornea after wearing night time lenses. The quality of vision is improved and amblyopia is prevented, subsequently allowing the use of other methods to correct refraction errors. Orthokeratology can be used to prevent amblyopia in myopic or myopic astigmatism patients. Life quality is much better in patients treated through orthokeratology, both by raising self-esteem and by lack of discomfort in wearing glasses [36].

THE NON-SURGICAL MANAGEMENT OF DIPLOPIA

When surgery addressing the cause of diplopia does not solve the disappearance of double vision, a corrective ophthalmologic treatment is still necessary, that will allow the patient to perform his daily routine activities. For smaller degrees of diplopia, achieving good binocular vision could be obtained by the use of prisms [37]. Their action is based on redirection of the light pathway in the affected eye, so that the images are eventually fused. In difficult cases, where proper reduction of double vision cannot be achieved by the previously described methods, monocular vision is preferable for a better functional performance of daily tasks - such as reading, writing and walking. Filters of various occlusive degrees or patches can be used for achieving monocular vision [1].

References


