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Surgical rehabilitation of patients with thyroid eye disease: systematic approach

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Aim — to analyze the results of surgical treatment of patients with thyroid eye disease (TED), including the type of surgery, indications, and outcomes. **Material and methods.** Hundred thirty-nine patients with TED (112 females, 27 males) aged 45.8±13.6 years. **Results.** Bony orbital decompression was performed in 91 patients (128 orbits). After the surgery, visual acuity increased from 0.84±0.47 up to 0.94±0.32 ($p<0.05$), exophthalmos got reduced by the average of 3.4 mm. Strabismus surgery was performed in 15 patients. The absence of diplopia in the primary position of gaze was achieved in 12 cases and the degree of residual heterophoria average 3.33 PD (2–6 PD). Ocular motility improved from 10.7° up to 34.58°. Eyelid surgery was performed in 81 patients. **Conclusions.** 1. Surgical treatment for thyroid eye disease is indicated in patients with visual impairment and/or significant decrease of life, if pathogenetic treatment fails. 2. The choice of surgical strategy depends on several factors, such as TED activity and severity, thyroid function, pathologic changes in the orbital tissues, and surgeon's experience and preference. 3. Current surgical techniques for thyroid eye disease enable correction of disease consequences, such as exophthalmos, optic neuropathy, impairment of ocular movement, and exposure keratopathy. 4. Adherence to the systematic approach that includes bony orbital decompression, strabismus surgery, and correction of lagophthalmos and eyelid retraction, ensures high-level functional and cosmetic rehabilitation in patients with TED.

Keywords: thyroid eye disease, surgical treatment, orbital decompression, restrictive strabismus, binocular diplopia, eyelid retraction, optic neuropathy, keratopathy.

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TED is an orbital inflammatory disease in which the pathological process and its consequences lead to changes in various structures, including orbital soft tissues, optic nerve, eyelids and ocular surface. According to literature about 20% of patients require surgery at any stage of the disease [1]. Surgical treatment of these patients is challenging and often turns out to be a long, multi-stage process, that is mostly due to the staging course and variability of signs and symptoms of the disease. Surgical interventions in active stage should be performed only in emergency cases and are focused on preventing the decrease of visual functions and their recovery in cases of compressive optic neuropathy or exposure keratopathy and corneal ulcer [2–6]. During the mild inflammatory stage, surgical treatment aims at patients' functional and cosmetic rehabilitation.

Surgical interventions in TED can be divided into 4 categories: orbital surgery aimed to lower intraorbital pressure and reduce exophthalmos; interventions on extraocular muscles to correct strabismus; eyelid surgery to correct their malpositions and lagophthalmos; cosmetic eyelid surgery (removal of orbital fat herniation and excess eyelid skin). This surgical sequence is generally approved, since the results of each intervention can directly influence the outcome of subsequent procedures [7, 8]. For example, orbital decompression leads to changes in globe and eyelids position and can also affect the extraocular muscles and cause a displacement of the muscle cone [9, 10]. In addition, it is difficult to evaluate the real degree of eyelid retraction in case of a pronounced protrusion of the globe or its nonaxial displacement in either horizontal or vertical direction or heterotropy. Cases of orbital autoimmune inflammation reactivation after the decompression have also been described [11]. Eyelid surgery is performed on the final stage of surgical treatment, since the recession of vertical rectus muscles can increase eyelid retraction due to the anatomic relation between these muscles and eyelid retractors [9, 12–14]. Any of the above-listed stages can be omitted if not indicated, but when it is necessary to perform all of them, one should follow the mentioned sequence.

Purpose — to analyze results of surgical treatment in patients with TED including variants, indications and results of procedures.

Material and methods

The present study is a retrospective analysis of clinical records of TED patients treated at the Scientific Re-

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search Institute of Eye Diseases from 2010 to 2016. Inclusion criteria were confirmed diagnosis of TED and an endocrinological evaluation. Patients with any changes in eyelids, orbit and extraocular muscles not related to the underlying disease were excluded from the study.

139 patients with TED (112 females, 27 males) aged 45.8±13.6 years were included into the study. The distribution of clinical observations in correlation with TED symptoms is presented in a **table**.

Clinical observations distribution in correlation with TED signs

Key signs	Number of observations (patients /eyes)
Exophthalmos	41/52
Optic Neuropathy	31/49
Exposure keratopathy	19/27
Strabismus	15/17
Upper eyelid retraction	52/82
Lower eyelid retraction	40/54

Patient examination included routine (external inspection, visometry, tonometry, biomicroscopy, ophthalmoscopy) and additional diagnostic tools (exophthalmometry, orbitometry, biometric measurements, photographic recording, binocular vision assessment). In addition, we assessed the globe position in the orbit: the axial position (exophthalmos) and the deviation from the rotation axes (heterotropy). In patients with strabismus, the angle of deviation in primary gaze position was determined using Hirschberg test and prism bars. Ocular motility was evaluated in 8 directions. Assessment of binocular diplopia area was carried out with the use of original software.

We performed multi-slice computed tomography (MSCT) in bone and soft tissue scanning modes both before and after orbital decompression to specify the orbital structures topography and anatomy, as well as their postoperative changes that could affect the globe position and motility.

In addition to routine ophthalmological examination, automated visual field testing, Ishihara color vision test, and, in some cases, optical coherence tomography were carried out to assess the optic nerve function.

TED activity was assessed using Clinical Activity Score (CAS): each symptom was given a score of 1. A score of 4 or more indicated active disease.

All patients enrolled into the study underwent at least 1 surgical procedure. Bony orbital decompression (BOD) was either lateral or balanced. Choice of the surgical technique depended on the following factors: the presence of compressive optic neuropathy, exophthalmos, apical orbital crowding according to MSCT scans, and orbit anatomy features.

Lateral BOD was performed using percutaneous approach. The osteotomy was carried out with a sagittal saw. The cut extended from the level of base of the skull to the level of orbital floor level along the bone suture between the greater wing of sphenoid and frontal bones. 5 mm of orbital margin was preserved. The osteotomy area was further extended removing sphenoid «triangle» (medullary space between the superior and inferior orbital fissures). The depth of the lateral BOD varied in different cases. After the bone window was formed and orbital periosteum dissected lacrimal gland, orbital fat and the external rectus muscle (partially) were displaced into the newly-formed cavity.

In balanced orbital decompression the above-mentioned technique was complemented with transmastoid or transconjunctival medial bony decompression. Transmastoid approach was performed by otolaryngologist and included polysinosotomy followed by medial orbital wall resection. In case of significant exophthalmos, the medial third of the lower orbital floor was additionally resected via the expanded opening of the maxillary sinus.

The main purpose of extraocular muscles surgery was to restore binocular vision and to reduce the diplopia zone as well as cosmetic improvement. Since the maximum (restrictive) limitation of the eye motility was observed with the eye moving in the direction opposite to the most affected muscle, particular attention was paid to increasing the volume of movements in this specific direction. In almost all cases rectus muscles recession — resection surgery was performed and, in one case, a complete tenotomy of the internal rectus muscle was performed.

Eyelid surgery, as well as extraocular muscles surgery, was carried out only after at least 6 months of normal thyroid function and no signs of orbital inflammation. Mild upper eyelid retraction was surgically corrected by transconjunctival Mullerotomy. In more severe cases, percutaneous full-thickness blepharotomy or recession of upper eyelid levator were performed. The lower retraction was corrected by lengthening of the retractors with a mucoperiosteal flap or other methods.

Results

The stages of surgical treatment, the number of performed interventions and the effectiveness of each stage were taken into consideration while evaluating the results. In this study, the results of cosmetic surgery of the upper and/or lower eyelids were not taken into account.

BOD was performed in 91 patients (128 operations in total) with 37 patients undergoing bilateral surgery. In 94 cases, lateral BOD was performed, in 34 cases — balanced lateral and medial BOD. It is significant that the balanced medial orbital wall resection in 23 cases was performed by the otorhinolaryngologist with the use of transethmoidal approach, and in 11 cases — with transconjunctival approach. Indications for BOD were as follows: optic neuropathy, corneal damage and cosmetically unacceptable exophthalmos (49, 27 and 52 cases, respectively). In 43 patients surgical intervention was performed

in the active stage of the disease after unsuccessful methylprednisolone pulse therapy.

After the surgical treatment mean best corrected visual acuity increased from 0.84± 0.47 to 0.94± 0.32 ($p<0.05$). Decreased visual acuity, as a rule, was revealed in patients with optic neuropathy: mean visual acuity in these patients was 0.71± 0.27 prior to the surgery and 0.9 ± 0.15 after BOD. It is important to note that the visual function impairment after the surgery was not observed in a single case. Before orbital decompression mean exophthalmos was 24.2 ± 4.2 mm (from 16 to 33 mm), decreasing after the surgery to 20.8 ± 3.9 mm (from 15 to 29 mm); the difference is statistically significant ($p < 0.05$) (**Fig. 1**). In patients with optic neuropathy, a significant improvement in the computer perimetry results, contrast and color sensitivity, and optical coherence tomography parameters was achieved.

BOD in conjunction with topical medications allowed reversing the corneal changes (ulcerative keratitis and epitheliopathy), however in 4 cases corneal haze resulted in decreased visual acuity.

In 47 patients BOD was the only intervention, while 44 patients required further surgical procedures. In 17.4% (4 eyes) cases a persistent convergent strabismus and binocular diplopia, that required extraocular muscles surgery, occurred after the balanced orbital decompression (**see Fig. 1, e, f**). In 6 patients strabismus and binocular diplopia were prior to BOD, no changes in deviation angle and eye motlity were identified after orbital surgery.

15 patients underwent extraocular muscles surgery. In 1 patient with TED, a lower rectus muscle surgery for vertical restrictive strabismus correction was the only surgical intervention. In the other 14 cases, the correction of strabismus was the next-stage surgery in a multistage TED treatment. In 6 patients, convergent strabismus was a complication of orbital decompression (in 2 cases it manifested after an endoscopic endonasal decompression of the medial wall of both orbits; in 4 cases — after a balanced decompression of the lateral and medial walls of both orbits). Convergent restrictive strabismus was noted in 6 patients: in 5 cases the eye was deviated downwards (hypotropia), and in 4 cases — a combined horizontal and vertical strabismus was registered (**see Fig. 1,c, f**). Mean horizontal strabismus angle was 23.3° (from 5° to 50°); vertical — 26.1 ° (from 10° to 45°). All patients had significant restriction of eye movements in the direction opposite to its deviation (i.e., towards the action of the ipsilateral antagonist muscle) (**Fig. 2**). In addition, eye motility in the same direction from the primary position was noted only in 7 patients and averaged from 5° to 15° (10.7°).

In 7 cases, orthotropia was achieved after a single surgical intervention (on one or two muscles), in 4 cases — after a two-stage extraocular muscles surgery and in 1 case — four interventions were performed consecutively (**Fig. 3**). As a result, in 12 patients binocular vision was restored in the primary gaze position and diplopia resolved; the mean heterophory was 3.33 PD (from 2 to 6

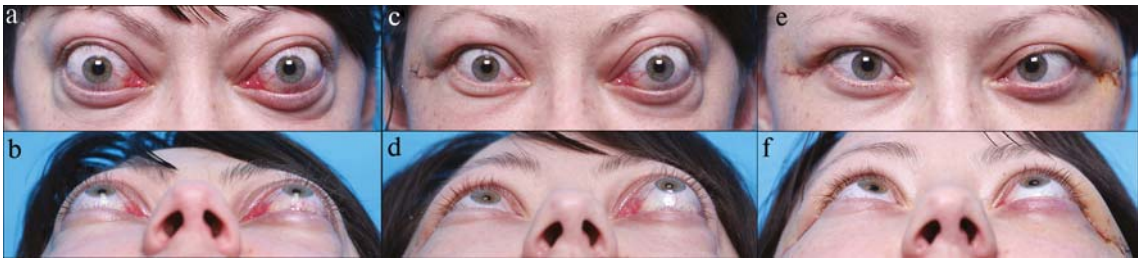

Fig. 1. **The patient before and after bilateral balanced orbital decompression.**

a — full face position before the surgery; b — semi-axial position before the surgery; c — full face position after the balanced decompression on the right side; d — semi-axial position after the balanced orbital decompression on the right side; e — full face position after the balanced orbital decompression on the left side. Note the postoperative convergent strabismus; f — semi-axial position after the balanced orbital decompression on the left side. Before the strabismus correction.

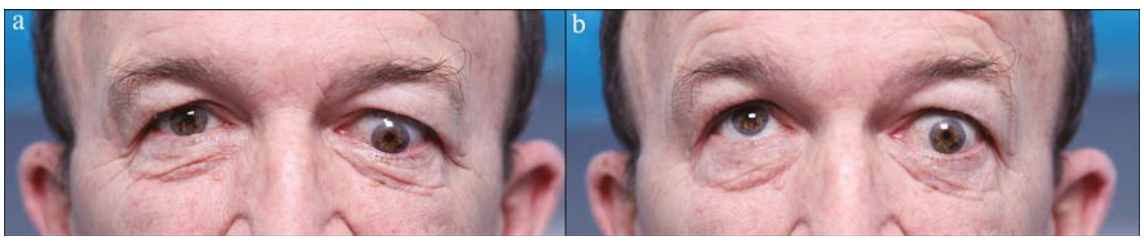

Fig. 2. **The patient after bony orbital decompression (lateral wall) on the left side. Restrictive vertical strabismus.**

a — hypotropia on the left side in the primary position of gaze; b — eye movements are restricted upward.

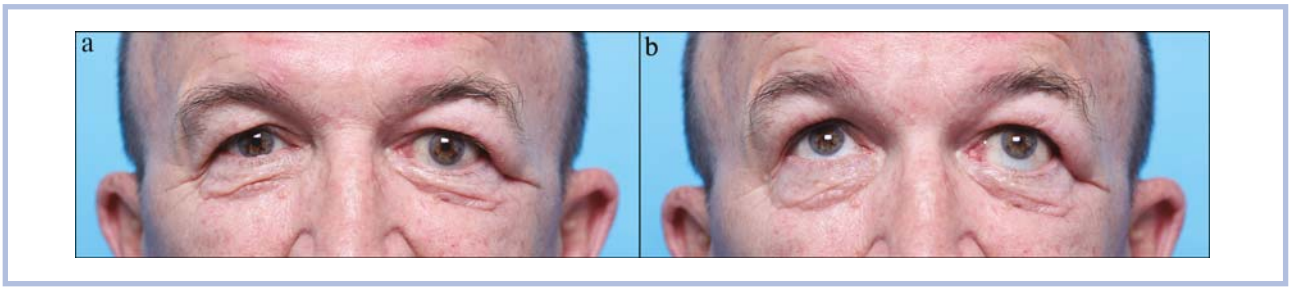

Fig.3. **Patient after left-sided vertical restrictive strabismus correction.**
a — orthotropia in the primary position of gaze; b — the full volume of movements of the left eye is restored.

PD). In 3 cases, the residual deviation angle averaged from 6.25° (от 3° до 10°), however central diplopia was corrected with prism glasses. In 1 case, after 2 months of treatment, diplopia recurrence was noted due to the reactivation of the underlying disease.

The eye motility improved in all cases, increasing by 35.83° on average compared to the initial position (**see Fig. 3**). It is noteworthy that, while evaluating the effectiveness of oculomotor disorders treatment, particular attention should be paid to an increasing volume of movements towards maximum movement restriction relative to the primary position — on average this indicator value equaled 34.58° (from 5° to 50°).

The eyelid surgery was performed in 81 patients: in 34 patients as the next stage of surgical treatment (32 patients after orbital decompression and 2 patients after orbital decompression and extraocular muscles surgery) and in 47 patients as the single stage. 52 patients (82 eyes) underwent upper eyelid retraction correction, in 30 cases it was performed bilaterally. Full-thickness blepharotomy was the most common method of retraction correction, performed in 45 eyes. Mullerotomy and levator recession were performed in 18 and 19 patients, respectively. In all patients normalization of the upper eyelid position was achieved. However, in some cases, the surgery was repeated with the aim of further correction or symmetry formation.

Correction of the lower eyelid retraction with mucoperiosteal flap acting as a spacer was performed in 40 patients (54 eyes), bilaterally — in 14. In all cases, a significant improvement in the lower eyelid position was achieved, however, in 8 eyes the residual retraction of ⩽1 mm remained.

In 14 patients with TED, pathologic changes of the eyelids and orbit were accompanied by a severe corneal lesion that required additional surgery: in 11 cases epikeratoplasty was performed using various materials (amnion, autoconjunctiva, donor's corneal disc, allosclera transplant); 2 patients underwent penetrating keratoplasty and 1 patient — lamellar keratoplasty. In 5 cases, due to transplant lysis and rejection, reoperation was carried out accompanied by complete or partial tarsorrhaphy in order to prevent repeated transplant lysis.

Thus, in 95 patients (68.3%) surgical rehabilitation included one stage: 47 cases — BOD, 47 cases — eyelid surgery, and 1 case — strabismus correction. Two-stage treatment was required in 40 patients (28.8%): in 30 cases, treatment included BOD and eyelid surgery, and in 10 cases — BOD and interventions on extraocular muscles. Only 4 patients (2.9%) underwent three types of surgery: orbit decompression, strabismus correction and eyelid retraction. Data is presented without taking into account cosmetic blepharoplasty.

Discussion

The literature on TED has highlighted that about 20% of patients require surgery at any stage of the disease [1]. Surgical treatment of these patients is rather more symptomatic than pathogenetic. The choice of a particular method depends on the disease stage and includes various interventions aimed to correct one or another TED symptom. The following sequence of surgical interventions is generally accepted: BOD, extraocular muscles surgery and, lastly, eyelid surgery.

In Russia, only the Scientific Research Institute of Eye Diseases provides the necessary conditions for all stages of TED patients' surgical rehabilitation.

The proposed systematic approach to surgical rehabilitation of TED patients implies conducting various consecutive interventions at different stages of the disease. In other studies, the authors suggest simultaneous surgical interventions [15]. However, we believe that in most cases this approach is unjustified, since it is impedes predicting the prognosis and only slightly reduces the amount of necessary surgical interventions.

It is important to note that of TED patients' treatment requires an interdisciplinary approach and close cooperation of various specialists, especially ophthalmologists and endocrinologists. Such cooperation is of a high importance, because most ophthalmological operations (with the exception of emergency indications, presenting a threat of rapid and irreversible changes of visual functions) require a stable thyroid hormones level.

Orbital decompression is the basis of surgical treatment for TED patients. This intervention can be per-

formed both in active and inactive stages of the disease. Optic neuropathy and severe corneal damage are menacing complications that can lead to persistent vision loss and usually occur during the active orbital inflammatory stage. In case of ineffective therapy with high doses of glucocorticoids, these patients need urgent surgical treatment, such as orbital decompression and in case of a corneal damage, keratoplasty and eyelid surgery are performed [2–5, 16]. In our study 47.2% patients underwent emergency BOD in the active phase of the disease. In other cases, the intervention was elective.

Despite the common perception of BOD as a very complex and traumatic technique with a high risk of postoperative complications, our study has shown its high efficacy and safety. For example, postoperative strabismus and binocular diplopia, more typical for medial decompression, are considered to be one of the most frequent BOD complications [6, 17]. In this study, no case of postoperative strabismus, diplopia or impaired eye motility was noted after performing lateral BOD. With a balanced BOD, the rate of postoperative strabismus was relatively low (17.4%) compared to other studies.

Current BOD techniques with a partial posterior removal of the greater wing of the sphenoid bone allow achieving positive result in case of so-called "woody orbit". Special characteristics surgery depend on the TED activity, indications, orbits topography and soft tissue changes, the incision location, the design of the window osteotomy, the decompression technique, and the volume of fat decompression.

Surgical procedures on the extraocular muscles should be performed only under conditions of inactive disease stage and at least 6 months of stable euthyroidism [18].

On the final stage of TED patient's surgical rehabilitation an eyelid surgery is performed. This intervention allows to narrow the eyelid opening (i.e., decrease the severity of exposure keratopathy symptoms), as well as improve patients appearance. In this study, the amount of eyelid interventions was relatively small due to dependency on the patient's subjective judgement of his appearance.

Given the complexity and staging, TED patients surgical rehabilitation should be performed in specialized institutions by surgeons who have a broad experience in orbit and ocular adnexa pathology.

Conclusion:

1. Surgical treatment of patients with TED is indicated in cases of visual functions impairment and/or significant decrease of life quality if pathogenic treatment fails.
2. Choice of surgical strategy depends on several factors such as activity and severity of thyroid eye disease, thyroid function, pathologic changes of orbital tissues and surgeon's experience and preference.
3. Current methods of surgical treatment of TED allow to manage such consequences of this condition as exophthalmos, optic neuropathy, ocular movement impairment and exposure keratopathy.
4. Compliance with methodical approach that includes bony orbital decompression, strabismus surgery, lagophthalmos correction and eyelid retraction provides a high level of functional and cosmetic rehabilitation of patients with thyroid eye disease.

Author's contribution:
Idea and study design: SA, YG
Data collection and analysis: YG, DI, SD, NS
Statistical analysis: DI, SD
Writing: DS, SD, PK
Editing: SA, YG

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