Surgical Treatment of Fourth Cranial Nerve Palsy: A Case Series

Tratamento Cirúrgico da Parésia do Quarto Par Craniano: Uma Série de Casos

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ABSTRACT

INTRODUCTION: Our purpose was to describe 4 cases of fourth cranial nerve palsy with different clinical presentations and corresponding tailored surgical techniques to correct ocular misalignment, diplopia and/or substantial abnormal compensatory head posture.

METHODS: Retrospective and observational case series study. All cases were followed in the Strabismus clinic of the Ophthalmology Department of Centro Hospitalar Universitário de S. João (Porto, Portugal).

RESULTS: Case 1 highlights a long-term congenital fourth nerve palsy in a 48-year-old patient with significant inferior oblique (IO) overaction, successfully corrected with a recession of the IO. Case 2 consists of a 43-year-old patient with subacute onset of iatrogenic fourth nerve palsy, successfully corrected with a superior oblique (SO) tuck (significant intraoperative laxity of the SO muscle was evident in the forced duction test). Case 3 highlights a congenital fourth nerve palsy in a 2-year-old patient, whose abnormal head posture persisted despite anterior transposition of the IO due to residual excyclotropia, which was afterwards successfully corrected with a Harada-Ito procedure. Case 4 consists of a 32-year-old healthy patient with subacute onset of idiopathic fourth nerve palsy (no history of trauma), who did not present IO overaction and had low potential for SO strengthening procedures. A recession of the ipsilateral superior rectus (SR) and the contralateral inferior rectus (IR) with 1 muscle-width nasal transpositions were successfully performed.

CONCLUSION: Fourth nerve palsies present multiple ocular motility patterns with varying degrees of SO underaction, IO overaction and cyclodeviations. To successfully correct them, one must study the affected patient extensively and understand the predominant anomaly, performing an individualized surgical treatment.

KEYWORDS: Ophthalmologic Surgical Procedures; Trochlear Nerve Diseases/surgery.

RESUMO

INTRODUÇÃO: O nosso objetivo foi descrever 4 casos distintos de parésia do quarto par craniano com diferentes apresentações clínicas e diferentes tratamentos cirúrgicos dirigidos, com

o propósito de corrigir o alinhamento ocular, diplopia e/ou posições cefálicas anómalas compensatórias.

MÉTODOS: Estudo retrospetivo e observacional do tipo série de casos. Todos os casos foram seguidos na secção de Estrabismo do departamento de Oftalmologia do Centro Hospitalar Universitário de S. João.

RESULTADOS: O primeiro caso aborda uma parésia congénita de longa duração do quarto par num doente de 48 anos, com hiperação significativa do oblíquo inferior (OI), corrigida com sucesso com uma retro-inserção do OI. O segundo caso aborda uma parésia iatrogénica subaguda do quarto par num doente de 43 anos, corrigida com sucesso com uma prega do oblíquo superior (OS), dada a laxidão significativa do tendão do OS detetada intra-operatoriamente com o teste das ducções forcadas. O terceiro caso retrata uma parésia congénita do quarto par craniano num doente de 2 anos, com persistência de posição anómala da cabeça após transposição anterior do OI, devido à presença de exciclotropia residual. Esta foi posteriormente corrigida com uma cirurgia de Harada-Ito. O quarto caso aborda uma parésia idiopática subaguda do quarto par, num indivíduo saudável de 32 anos sem história de trauma, sem hiperação do OI e com baixo potencial de resolução através de técnicas de fortalecimento do OS. Foram realizadas retro-inserções do reto superior (RS) ipsilateral e do reto inferior (RI) contralateral com transposições nasais de largura equivalente à dos próprios músculos, com sucesso.

CONCLUSÃO: As parésias do quarto par craniano apresentam múltiplas alterações da motilidade ocular, com graus variáveis de hipoação do OS, hiperação do OI e ciclodesvios. Para as corrigir com sucesso, é necessário estudar extensivamente o doente afetado e perceber a anomalia predominante, com tratamento cirúrgico individualizado.

PALAVRAS-CHAVE: Doenças do Nervo Troclear/cirurgia; Procedimentos Cirúrgicos Oftalmológicos.

INTRODUCTION

The fourth (trochlear) cranial nerve is responsible for supplying only the superior oblique (SO) muscle contralateral to its nucleus. It is an extremely long and slender nerve, with a long intracranial course, increasing its vulnerability to lesions due to head trauma. It has the fewest axons of any cranial nerves. Furthermore, it is the only cranial nerve to emerge from the dorsal aspect of the brainstem and the only decussated cranial nerve, besides the optic nerve.[1] Although sixth nerve palsy has been reported as the most common type of extraocular muscle palsy in adults in most studies,[2-4] fourth nerve palsy is the most frequent congenital cranial nerve palsy and also the most frequent cranial nerve palsy in children.[5] In fact, in children, the most common category of third and fourth nerve palsies is congenital, while sixth nerve palsy is usually due to infections and immunologic processes.[4,6] Nevertheless, in adults, the most frequent cause of third and sixth nerve palsy is microvascular disease associated with systemic risk factors (such as hypertension and diabetes, which may account for up to around 40% of isolated third nerve palsies[1,4]), while trauma is the leading cause of fourth nerve involvement, especially when it is bilateral.[1,4,7,8] Other causes of isolated fourth nerve palsy include idiopathic lesions, which are surprisingly common, though many are thought to be congenital, with symptoms only developing in adult life due to reduced fusional ability. These usually result in vertical diplopia with a sudden or subacute onset, but not in torsional diplopia. Examination of old photographs for the presence of a compensatory head posture may be helpful for the diagnosis, as well as the presence of an increased vertical prism fusional range.[1] Furthermore, microvascular lesions are also a relatively common cause of fourth nerve palsy. These are frequently assumed when appropriate systemic risk factors are present and in the absence of features of congenital onset. Other causes, such as aneurysms or tumors, are extremely rare.[1,4,5,8]

Regarding its clinical signs, the acute onset of vertical diplopia in the absence of ptosis, combined with a characteristic head tilt posture strongly suggests fourth nerve disease. Nuclear lesions result in contralateral while peripheral lesions cause ipsilateral SO weakness. Involvement of the right fourth cranial nerve results in right hypertropia in primary position, usually increasing on left gaze, with elevation in adduction of the right eye (OD), due to the unopposed action of the right inferior oblique (IO). Furthermore, there is a limitation of depression of the OD, most marked in adduction, which is predictable since this is the field of action of the right SO muscle. Usually, there is also a compensatory head posture to prevent torsional and vertical diplopia. To compensate for decreased intorsion and depression of the OD, the patient assumes a contralateral head tilt with a slight chin depression.[1,5,7] Bilateral fourth nerve

involvement may result in right hypertropia in the left gaze and left hypertropia in the right gaze, with a significantly associated cyclodeviation and a V pattern esotropia.[9] The Parks-Bielschowsky three-step test is usually sufficient to corroborate the diagnosis of a fourth cranial nerve palsy.

When it comes to the treatment of fourth nerve palsies, congenital and presumed microvascular palsies frequently resolve spontaneously. However, strabismus surgery is required for troublesome diplopia and/or significant compensatory head postures. The surgical approach depends on the pattern and the severity of the SO weakness. The Knapp classification may help establish the surgical procedure.[10] For cases with small hypertropia (<15 prism diopters (PD)) and inferior oblique overaction, weakening procedures of the IO muscle are usually performed. They include myectomy, recession, and anterior transposition.[1,11] Nonetheless, if there is no IO overaction, the surgical options include the recession of the ipsilateral superior rectus (SR) muscle or the contralateral inferior rectus (IR) muscle. For moderate to large vertical deviations, (>15 PD), IO weakening procedures can be combined with a recession of ipsilateral SR or contralateral IR, or both.[12] The forced duction test (FDT) of the oblique muscles, usually performed intraoperatively, is extremely useful in the identification of a lax SO tendon, often seen in cases with congenital palsy. In such cases, SO tuck is the recommended procedure.[13] Excyclotorsion may also need to be addressed, particularly in bilateral cases with torsional diplopia and significant cyclodeviations (>10º). The Harada-Ito procedure has been described for such cases and involves splitting the superior oblique and advancing the anterior half of the tendon. The advantage of this procedure is that the vertically acting posterior fibers are left undisturbed, and only the anterior fibers (responsible for torsion movement) are operated upon. The Harada-Ito procedure has been classically described for objective significant cyclodeviations (>10º), but it has been increasingly performed for lesser deviations by some surgeons.[14]

The purpose of this work is to describe 4 different cases of fourth cranial nerve palsy with different clinical presentations and corresponding tailored surgical techniques to correct ocular misalignment, diplopia and/or substantial abnormal compensatory head posture.

METHODS

Single-center, retrospective, and observational case report study with description of 4 distinct cases of symptomatic fourth nerve palsy with resultant complaints of diplopia or abnormal head posture. All cases were followed in the Strabismus clinic of the Ophthalmology Department of Centro Hospitalar Universitário de S. João (Porto, Portugal), a tertiary university hospital that serves the northern region of Portugal. The research adhered to tenets of the Declaration of Helsinki and approval for this study was waived from the Ethics Committee of the Hospital, since this an extended case report. All subjects included provided written informed consent for the research and its publication.

These 4 cases were selected out of 22 cases we have followed in our Strabismus clinic, since each presented distinct ocular motility disorders, requiring a different surgical treatment and were well documented with photographs of the ocular movements in the nine positions of gaze and/or presented Hess charts and/or photographs of the Bielschowsky head tilt test.

Criteria required for a "successful" outcome included: (1) hyperdeviation of 5 PD or less in primary position of gaze (PPG); (2) elimination of any compensatory abnormal head posture; (3) elimination of diplopia in the central 30º of the binocular visual field. These criteria are the same as those used in many published studies regarding the outcomes of different surgical techniques for treating fourth nerve palsy with SO underaction.[1]

Although one of the cases we present did not meet the criteria for a successful outcome, we valued the fact that in this case there was elimination of both abnormal head posture and diplopia in all positions of gaze, despite the 7 PD hyperdeviation and 6 PD exodeviation of the affected eye in PPG. All four patients were extremely satisfied with their outcomes, as reported below.

RESULTS

CASE 1

A 48-year-old male was observed in our Strabismus clinic due to vertical diplopia in right gaze since the patient was 15 years old, which had worsened over time, being now also present in primary position of gaze (PPG). The patient presented medical history of systemic hypertension. The best corrected visual acuity (BCVA) was 0.0 logMAR units for the OD and the left eye (OS). The anterior segment presented no relevant abnormalities, intraocular pressure (IOP) was within normal limits and the ocular fundus was also normal in both eyes (OU). The patient presented an OS hypertropia and exotropia, head tilt to the right, decreased depression in adduction and left IO overaction, which was compatible with a left fourth nerve palsy. This was probably a congenital palsy, as the patient had complaints since adolescence. The Bielschowsky test was positive on head tilt to the left. Prism cover test measured an 18 PD vertical deviation in PPG, for far fixation. Preoperative photographic documentation of ocular movements is illustrated in Fig. 1. Given the angle of deviation and the left IO overaction, we opted for an IO 14 mm recession, placing it 2 mm posteriorly to the lateral border of the true IR insertion and 0 mm superiorly, considering a perpendicular line to the lateral border of the IR, as previously suggested by Apt *et al*.[16] In the latest evaluation at our Strabismus clinic, 6 months after the surgical procedure, the patient presented an OS hypertropia (7 PD for far fixation) and exotropia (6 PD for far fixation) in PPG (illustrated in Fig. 2). Furthermore, a residual left IO overaction persisted. Nonetheless, there was no postoperative diplopia in any position of gaze and the patient was extremely satisfied with the visual outcome of the procedure.

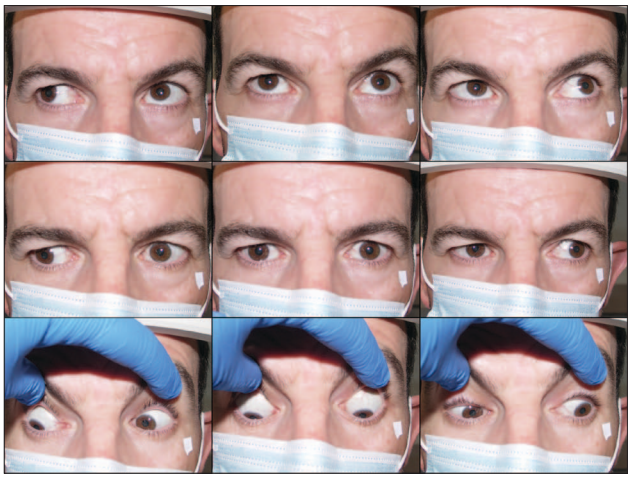

Figure 1. Case 1 preoperative photographs depicting the ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far.

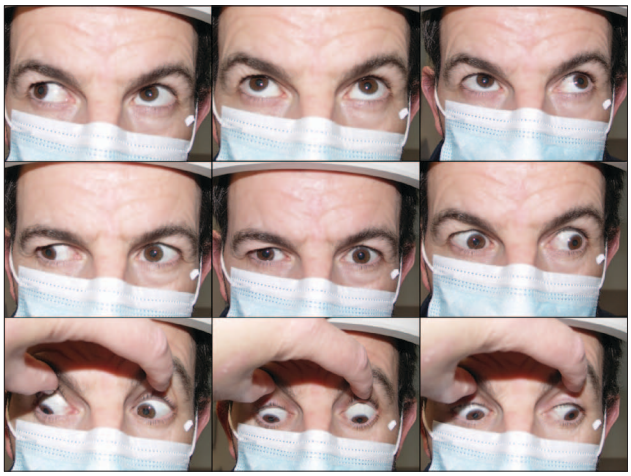

Figure 2. Case 1 postoperative photographs depicting the ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far. These were captured six months after the 14 mm recession of the left inferior oblique (IO).

CASE 2

A 43-year-old female was admitted to our Strabismus clinic due to subacute onset of vertical diplopia in PPG and in dextroversion, following surgery to remove a left posterior meningioma in the cerebellar tentorium, which probably damaged her left fourth cranial nerve. The patient presented no other relevant systemic or ocular history. In the first evaluation at our Strabismus clinic, the patient presented an uncorrected distance visual acuity (UDVA) of 0.0 logMAR units in OU. There were no relevant abnormalities in the anterior and posterior segment examination. The oculomotor examination revealed an OS hypertropia and exotropia for far fixation which increased in dextroversion, head tilt to the right, decreased depression in adduction and left IO overaction, which was compatible with a left fourth nerve palsy. The Bielschowsky test was positive on head tilt to the left. The prism cover test measured an OS 20 PD vertical deviation and a 9 PD exodeviation in PPG for far fixation. Preoperative photographs of the ocular alignment in the nine positions of gaze are presented in Fig. 3. Given the large vertical deviation and the IO overaction, the initial surgical procedure contemplated was a left IO anterior transposition. However, intraoperatively, a lax right SO tendon was identified in the FDT of the oblique muscles. Thus, our experienced strabismus surgeons (JB and AM) opted for an OS 8 mm SO tuck. In the first 6 months after the procedure, the patient developed a transient iatrogenic Brown with diplopia in supradextroversion, which eventually resolved one year after the procedure. The patient has now been followed for six years after the surgical procedure, remaining extremely satisfied with its outcome. UDVA remains 0.0 logMAR units in OU, with no abnormal head posture and no diplopia in all positions of gaze. Furthermore, the prism cover test with far fixation only reveals a 3.5 PD hypertropia and 3.5 PD exotropia of the OS and there is no left IO overaction or other ocular motility abnormalities (illustrated in Fig. 4).

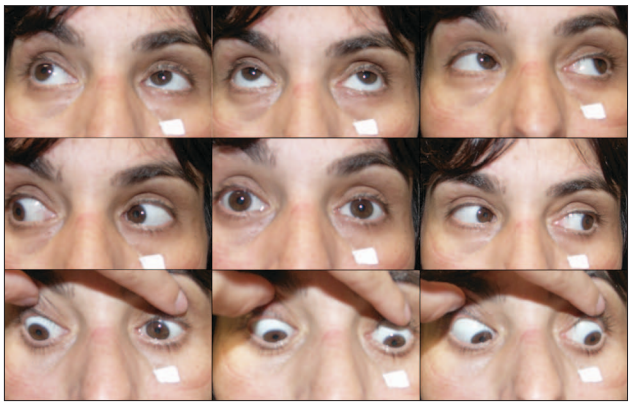

Figure 3. Case 2 preoperative photographs depicting the ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far.

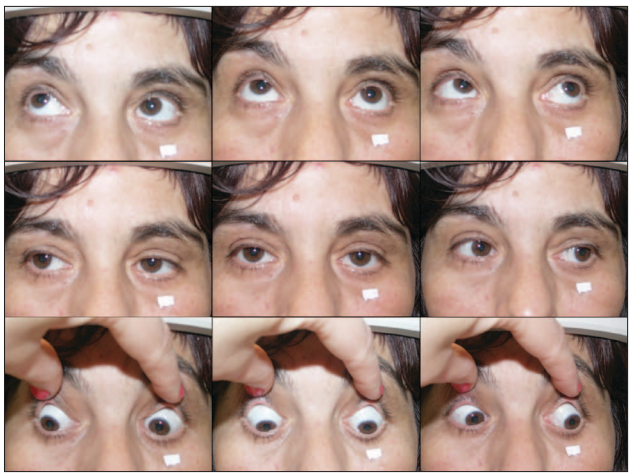

Figure 4. Case 2 postoperative photographs depicting ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far. These were captured three years after the left superior oblique (SO) 8 mm tuck, demonstrating normal ocular movements.

CASE 3

A 2-year-old female patient was referred to our Strabismus clinic due to an abnormal head posture with a head tilt to the right. There was no relevant systemic or ophthalmological history. In the first evaluation in our clinic, an OS hypertropia with left IO overaction were observed, though no left SO underaction could be demonstrated due to poor cooperation. The Krimsky test demonstrated a 20 PD OS hypertropia, but due to poor cooperation, the results were not very accurate, the prism cover test could not be performed, and preoperative photographs could not be captured. Given that the primary ocular motility disorder was the OS IO overaction, we decided to perform an anterior transposition of the left IO muscle, explaining to the parents that additional surgery could be required. Six months after this initial procedure, the patient still presented an abnormal head posture. In this visit, the patient was more collaborative, which allowed us to capture photographs in the nine positions of gaze (Fig. 5). No heterotropia was detectable in the cover-uncover test and ocular movements were preserved. However, the Bielschowsky test was positive on head tilt to the left (Fig. 5). These findings were compatible with a left fourth nerve palsy, with a likely congenital etiology. Nonetheless, the patient did not present any residual overaction of the left IO after the IO recession. Thus, the head tilt to the right was a compensation for OS excyclotropia due to torsional underaction of the left SO. As such, an OS Harada-Ito procedure was proposed and accepted by the patient's parents. Six months after this second surgical procedure, there was no detectable abnormal head posture, no evidence of left IO overaction and the Bielschowsky head tilt test was negative. One year after the second surgical procedure, the now 4-year-old patient collaborated in the visual acuity examination, presenting an UDVA of 0.1 logMAR units in OU (tested with the Allen figure chart). In the latest visit to our Strabismus clinic, 3 years after the second surgical procedure, the now 8-year-old patient presented an UDVA of 0.0 logMAR units (tested with the Snellen chart), with no abnormal head posture, no heterotropia in the cover-uncover test, normal ocular motility in the nine positions of gaze (Fig. 6), negative Bielschowsky test (Fig. 6) and normal stereopsis (determined with the Lang stereotest).

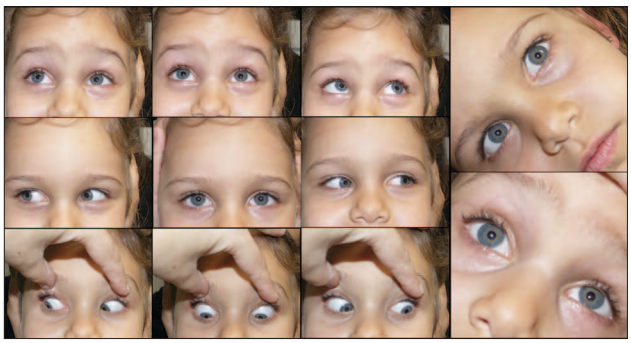

Figure 5. Case 3 photographs depicting ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far, and the Bielschowsky head tilt test. These were captured six months after the left inferior oblique (IO) anterior transposition and demonstrate normal ocular movements, but a positive test with head tilt to the left.

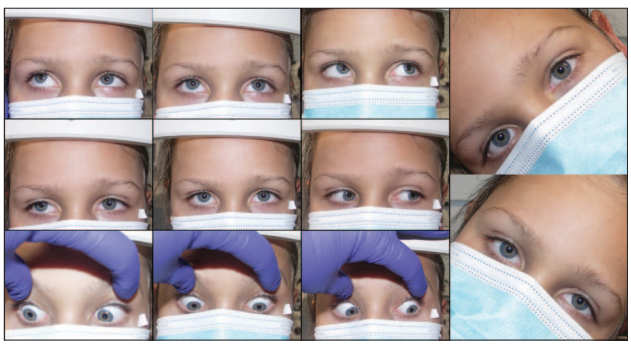

Figure 6. Case 3 photographs depicting ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far, and the Bielschowsky head tilt test. These were captured four years after the Harada-Ito procedure and four years and 10 months after the left inferior oblique (IO) anterior transposition, demonstrating normal ocular movements and a negative test.

CASE 4

A 32-year-old male patient was observed in our Strabismus clinic due to subacute onset of vertical and torsional diplopia in PPG with one year of duration. This feature worsened in dextroversion, and the patient presented an abnormal head posture with head tilt to the right. There was no relevant systemic or ophthalmological history and no history of any type of previous trauma. UDVA was 0.0 logMAR units in OU and the anterior segment, IOP and posterior segment examinations were normal. Regarding ocular motility, the patient presented an OS hypertropia and a Bielschowsky test positive with left head tilt, which were compatible with a left fourth nerve palsy. Nonetheless, there was no overaction of the left IO. The prism cover test determined a 17 PD OS hypertropia in PPG. Preoperative photographs in the nine positions of gaze were obtained (Fig. 7). Since there was no overaction of the left IO and there was a significant underaction of the left SO with OS hypertropia and excyclotropia (without any left SO tendon laxity detected intraoperatively), the potential success of SO strengthening procedures was very limited. Thus, our experienced surgeons (JB and AM) opted to perform a 3-4 mm recession of the right IR with 1 muscle-width nasal transposition, as well as a 6-7 mm recession of the left SR with 1 muscle-width nasal transposition. The nasal transpositions were performed as described in the literature[17]: the temporal suture of the IR/SR was aligned to the nasal border of the original IR/SR insertion and the nasal suture of the IR/SR was aligned to the inferior or superior portion of the MR, respectively. Therefore, with this option, we were able to correct the OS hypertropia and excyclotropia, without interfering with the left IO (which did not present any overaction) or the SO (which did not present tendon laxity and was significantly affected by the left fourth nerve palsy). Six months after the procedure, there were no heterotropias detected in the cover-uncover test, the Bielschowsky test was negative, and the patient did not present any diplopia or abnormal head position. Six years after the

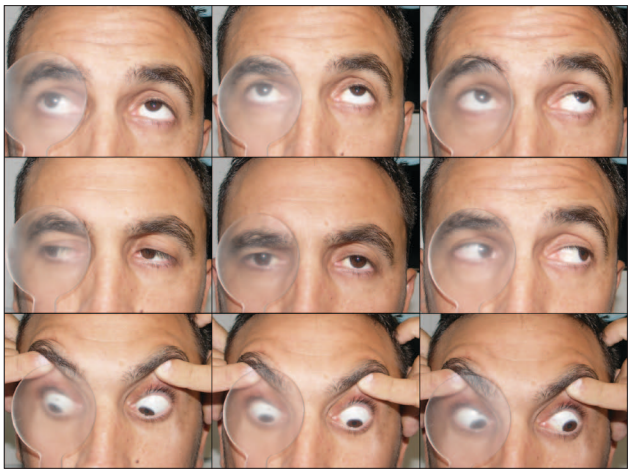

Figure 7. Case 4 preoperative photographs depicting ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far.

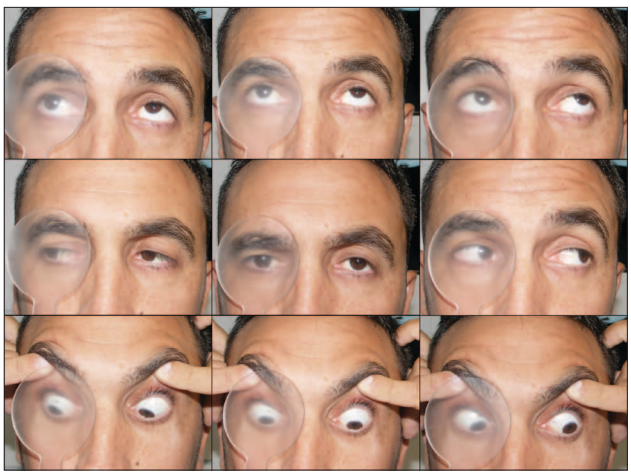

Figure 8. Case 4 postoperative photographs depicting ocular alignment in the nine positions of gaze, with left eye (OS) fixation for far. These were captured one year after the 3-4 mm recession of the right IR with 1 muscle-width nasal transposition and 6-7 mm recession of the left SR with 1 muscle-width nasal transposition. The ocular motility is preserved.

procedure, the patient remained satisfied, with no complaints of diplopia, no abnormal head posture, an UDVA of 0.0 logMAR units in OU and a normal ocular motility examination (Fig. 8).

DISCUSSION

In our study, we present 4 different cases of fourth cranial nerve palsy with different clinical presentations and corresponding tailored surgical techniques to correct ocular misalignment, diplopia and/or substantial abnormal compensatory head posture.

In the first 3 cases, there was a significant IO overaction secondary to the ipsilateral fourth cranial palsy. Currently, surgical procedures that are performed on the overacting IO muscles include recession, myectomy, disinsertion, denervation, denervation and extirpation, and anterior transposition.[18] The decision on surgical options will depend to a great extent on the activity of its antagonist, the SO muscle, and its tendon. When comparing various IO weakening procedures, Parks concluded that the recession procedure was superior.[18,19] The major advantage of the recession is that it allows the weakening procedure to be titrated according to the severity of the overaction. For 1+ or 2+ overaction, the inferior oblique muscle is recessed 10 mm for 3+ overaction, 12 mm; and for 4+ overaction, 14 mm, which is the maximum recession.[16,20] In the study by Parks *et al*, after a 2-year follow-up, 15% of patients had a return of overaction with the recession procedure, compared with 79% with myectomy at the origin, 53% with disinsertion, and 37% with myectomy at the insertion. These latter procedures have been progressively abandoned due to their lack of efficacy in correcting IO overaction. The denervation and extirpation procedure, while useful for 4+ overaction of the IO muscle, permanently correcting it, and for residual IO overaction after disinsertion, myectomy or recession of the IO muscle, has the disadvantage of permanent underaction of the IO muscle and inability to perform a future anterior transposition if a dissociated vertical deviation (DVD) develops. The other often used procedure to weaken the IO muscle is the anterior transposition (which was used in Case 3 initially). Initially described by Elliot *et al*,[21] the anterior transposition consists of transposing the IO muscle anteriorly toward the insertion of the IR muscle. When compared to the recession procedure, the anterior transposition was more effective in reducing persistent postoperative IO overaction.[21] However, there is a higher frequency of deficiency in primary position elevation (anti-elevation syndrome) with the anterior transposition of the IO muscle, when compared to the usual recession surgery (73% *vs* 25% in the study by Elliot *et al*[21]). Therefore, due to its powerful weakening ability, the anterior transposition should be reserved for patients with moderate to severe IO muscle overaction and for patients with bilateral IO muscle overaction and DVD.[22]

Regarding the indication for isolated IO muscle surgery in fourth nerve palsies, Hatz *et al* followed 47 patients with unilateral fourth nerve palsy for 1 year who underwent either single-muscle surgery (anteriorization or recession of the IO muscle) or two-muscle surgery (anteriorization of the IO muscle combined with recession of the contralateral IR muscle according to the amount of vertical deviation).[23] In their study, the authors concluded that isolated IO muscle weakening is an effective treatment option for SO palsy up to 15 PD of vertical deviation in primary position, while two-muscle surgery should be reserved for patients with larger vertical deviations (>15 PD) in primary position. Nonetheless, in our first case, we were able to correct a preoperative vertical deviation of 18 PD in PPG to a postoperative 7 PD vertical deviation, without any accompanying diplopia or abnormal head position, with a single 14 mm recession of the IO muscle. While this result might not be considered successful by some published criteria,[15] our patient was extremely satisfied with his result and declined the need for any additional surgery. In our third case, the

isolated anterior transposition of the IO muscle completely corrected a 20 PD vertical deviation in primary position. Therefore, the 15 PD limit for isolated or combined two-muscle surgery must be interpreted cautiously and applied in conjunction with the experience of the strabismus surgery, albeit it is an excellent reference for less experienced strabismus surgeons.

As for our second case, a SO tuck was successfully performed due to significant laxity of the SO tendon, identified intraoperatively with the FDT. We obtained excellent results with this procedure in this patient, given that there were no abnormal head postures, diplopia, or ocular motility abnormalities afterwards, with a residual 3.5 PD hyperdeviation and exodeviation of the OS, in PPG. Recently, Dwivedi *et al* conducted a large retrospective study of isolated SO tuck performed by a single surgeon over 25 years in cases of SO palsies, including 162 eyes from 162 patients and performing a mean amount of muscle tucking of 9.75 mm.[13] In their study, while there was a significant reduction of the vertical deviation in PPG in 97% of the included eyes, there was also an average residual deviation of 5 PD. Furthermore, while 85% of the included patients experienced improvement of diplopia postoperatively, 33% required additional surgery to further reduce diplopia. Therefore, while this procedure may be suitable for some patients with fourth nerve palsy, more demanding patients or patients with more significant OS underaction/IO secondary overaction may not be good candidates for isolated SO tuck, even if there is an important laxity of the SO tendon. Combining this surgery with other procedures (such as IO muscle weakening procedures) may be a better option for these latter cases.

Finally, the Harada-Ito procedure has become the superior option for fourth nerve palsies (unilateral or bilateral) with torsional diplopia due to excyclotropia.[14] This procedure involves transposing the detached anterior SO muscle fibers toward the insertion of the LR muscle, usually 7 to 8 mm posterior to the insertion of the LR.[14] This induces/enhances the intorsion ability of the paretic SO muscle without affecting its posterior fibers, which act more as depressors of the eye. While there is usually a more relevant cyclodeviation in bilateral fourth nerve palsies, some cases of unilateral palsy may also result in torsional diplopia/excyclotropia, as in our third case. In the study by Bradfield *et al*,[14] 73% of the patients achieved surgical success after Harada-Ito surgery and experienced no postoperative diplopia in the primary position at distance and downgaze at near. Bilateral Harada-Ito surgery produced more torsion correction than unilateral surgery (mean, 12.0º *vs* 8.4º; p=0.07) and patients with <10º of preoperative torsion had a better outcome. In their study, combining the Harada-Ito procedure with vertical muscle surgery did not result in a higher excyclotorsion correction. Similarly, in our third case, the Harada-Ito procedure successfully corrected the abnormal head tilt, probably due to a torsional diplopia that the patient could not express, considering her young age. Even though she had already been submitted to an anterior transposition of the IO muscle, the Harada-Ito was also needed to correct the excyclotropia. Fundus photographs and the double Maddox rod test would have been useful to document the excyclodeviation, but unfortunately the young patient was not able to cooperate. Nevertheless, the outcome was extremely satisfactory for the patient and the patient's parents.

To conclude, fourth nerve palsy can present several distinct ocular motility patterns with varying degrees of SO underaction, IO overaction, and cyclodeviation. To successfully eliminate diplopia and abnormal head posture, as well as to normalize ocular movements, one must study the affected patient extensively and understand the predominant anomaly, performing a tailored surgical treatment. Nonetheless, even with an individualized and careful approach, a significant number of patients will require additional surgery. As long as this is explained to the patient and there is a good doctor-patient relationship, good results should be expected in the long run.

CONTRIBUTORSHIPS TATEMENT / DECLARAÇÃO DE CONTRIBUIÇÃO:

RVM: Collected clinical data, redacted the manuscript, and contributed to its revision.

AFM, PFC, RS, OF, FFR and JB: Contributed to the redaction and revision of the manuscript.

AM: Developed the clinical investigation hypothesis, designed the study methodology and contributed to the redaction and revision of the manuscript.

All authors approved the final version.

RESPONSABILIDADES ÉTICAS

Conflitos de Interesse: Os autores declaram a inexistência de conflitos de interesse na realização do presente trabalho.

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Confidencialidade dos Dados: Os autores declaram ter seguido os protocolos da sua instituição acerca da publicação dos dados de doentes.

Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pela Comissão de Ética responsável e de acordo com a Declaração de Helsínquia revista em 2013 e da Associação Médica Mundial. O consentimento dos doentes para publicação obtido.

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