UNIVERSIDADE DE SÃO PAULO
FACULDADE DE MEDICINA DE RIBEIRÃO PRETO

BRUNA SÂMARA NOGUEIRA EQUITÉRIO

Efeito da descompressão orbitária na morfologia da fenda palpebral em pacientes com orbitopatia de Graves

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Tese apresentada à Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo para obtenção do Título de Doutor em Ciências.

Área de Concentração: Mecanismos Fisiopatológicos dos Sistemas Visual e Áudio-Vestibular.

Orientador: Prof. Dr. Antonio Augusto Velasco e Cruz

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FOLHA DE APROVAÇÃO

Aluno: Bruna Sâmara Nogueira Equitério

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Dedicatória

Dedico este trabalho às pessoas mais importantes da minha vida, aquelas que estão presentes em todos os momentos, que fazem parte da minha história, aos meus pais Elaine e Ronaldo e aos meus irmãos Barbara e Anderson.

Agradecimento

Agradeço ao meu orientador, **Prof. Dr. Antonio Augusto Velasco e Cruz**, que honra o título de professor com maestria, inspirando, ensinando, partilhando suas experiências, histórias e boas risadas.

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Resumo

EQUITÉRIO, B. S. N. **Efeito da descompressão orbitária na morfologia da fenda palpebral em pacientes com orbitopatia de Graves.** 2023. 93f. Tese (Doutorado) - Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo. Ribeirão Preto. 2023.

Este estudo aborda as anomalias de contorno palpebral em pacientes com orbitopatia de Graves (OG) e a importância de se entender a morfologia palpebral para uma correção cirúrgica eficaz. Quatro artigos resultaram desta investigação. O primeiro é uma revisão sistemática sobre a descompressão lateral profunda que mostrou a inexistência da padronização da cirurgia e de dados referentes à remoção da parede lateral na morfologia da fenda palpebral. O segundo versa sobre a determinação do "flare" lateral (FL) em pacientes com OG. Propõe um método objetivo para definir se o paciente apresenta ou não esse sinal. O estudo identifica que a medição da distância lateral da linha que passa pela pupila até a margem da pálpebra, 2,5 mm medial ao canto lateral, é sensível e específica para diagnosticar o FL. O artigo seguinte analisa os efeitos da descompressão orbitária na morfologia palpebral em pacientes com OG inativa. A pesquisa sugere que a proptose exerce papel secundário na retração lateral da pálpebra, e a redução da proptose não está diretamente correlacionada com a redução do FL. Por fim, o quarto trabalho aborda a remoção do rebordo orbitário durante a descompressão orbitária, mostrando que não há diferença significativa na forma da fenda palpebral entre pacientes com o rebordo removido ou mantido. Concluindo-se que a remoção do rebordo orbitário durante a descompressão não causa efeitos prejudiciais significativos na morfologia da fissura palpebral.

Palavras-chave: Orbitopatia de Graves. Descompressão orbitária. *Flare*. Retração palpebral. Rebordo orbitário.

Abstract

EQUITÉRIO, B. S. N. **Effect of orbital decompression on palpebral fissure morphology in patients with Graves' Orbitopathy.** 2023. 93f. Thesis (Doctoral) - Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo. Ribeirão Preto. 2023.

This study addresses eyelid contour anomalies in patients with Graves' orbitopathy (GO) and the importance of understanding eyelid morphology for effective surgical correction. Four papers stem from this investigation. The first one is a systematic review on deep lateral orbital decompression, which demonstrated the lack of standardization in surgery and data regarding the removal of the lateral wall in the morphology of the eyelid fissure. The second one focuses on determining lateral "flare" (FL) in GO patients and proposes an objective method to ascertain whether a patient exhibits this sign. The study identifies that measuring the lateral distance from the line passing through the pupil to the eyelid margin, 2.5 mm medial to the lateral canthus, is sensitive and specific for diagnosing FL. The following paper analyzes the effects of orbital decompression on eyelid morphology in patients with inactive GO. The research suggests that proptosis plays a secondary role in lateral eyelid retraction, and the reduction of proptosis is not directly correlated with FL reduction. Finally, the fourth paper addresses the removal of the orbital rim during orbital decompression, demonstrating that there is no significant difference in the shape of the palpebral fissure between patients with the rim removed or preserved. It concludes that the removal of the orbital rim during decompression does not cause significant adverse effects on palpebral fissure morphology.

Key words: Graves' Orbitopathy. Orbital decompression. Flare. Eyelid retraction. Orbital rim.

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Lista de Símbolos e Abreviaturas

CAS- *Clinical Activity Score*

DP- Desvio padrão

FL- *Flare* lateral

FO- Fibroblastos orbitários

IL- Interleucina

MEPS- Músculo elevador da pálpebra superior

OG- Orbitopatia de Graves

TRAB- Anticorpo antirreceptor de TSH

TSH- Hormônio estimulador da tireoide

TSHR- Receptor de TSH

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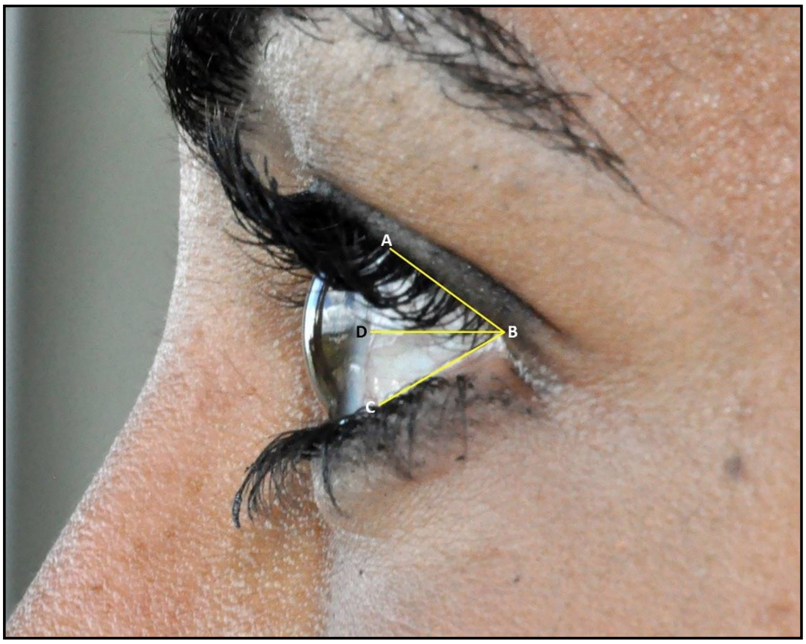
1- Introdução

1.1 Fenda palpebral

A fenda ou fissura palpebral compreende o espaço delimitado pela pálpebra superior e inferior. Devido à presença do globo ocular, a fenda pode ser definida como uma estrutura tridimensional contendo, além da altura e largura, a profundidade anteroposterior (CRUZ; LUCCHEZI, 1999).

Apesar do formato tridimensional atribuído à fenda palpebral, normalmente ela é avaliada considerando-se apenas duas dimensões, com o paciente em alerta e na posição primária do olhar. Em um elegante estudo conduzido por Malbouisson, Baccega e Cruz (2000), os autores demonstraram que a parte ciliar, tanto da pálpebra superior como da pálpebra inferior, define um polinômio de segundo grau, ou seja, uma parábola. O estudo chama ainda atenção para a posição do canto lateral, que está cerca de 1.48 mm atrás do plano frontal e 10.01 mm posterior ao ápice da córnea. Dessa forma, o canto lateral não está alinhado com o equador do olho, que normalmente está a 12 mm posterior ao ápice da córnea. Os autores mostraram ainda que o ângulo do canto lateral pode ser dividido em um componente superior de 29.74º e um inferior de 34.96º (Figura 1). O estudo provou, matematicamente, que a parte central do contorno superior se encaixa perfeitamente em uma esfera, nesse caso, o globo ocular. Pode-se, então, concluir que o formato da pálpebra superior está associado à posição do olho na órbita.

Figura 1 - Ângulo do canto lateral dividido em um componente superior de 29.74º entre A e D e um inferior de 34.96º entre D e C



Van Den Bosch, Tjon-Fo-Sang e Lemij (1998) conduziram um estudo sobre a posição palpebral em pacientes com orbitopatia de Graves (OG) submetidos à descompressão orbitária inferomedial. Os autores analisaram 63 pálpebras de pacientes submetidos à descompressão transantral inferomedial e 90 pálpebras de pacientes controle. Para evitar possíveis vieses relacionados ao sexo dos pacientes envolvidos no estudo, incluíram apenas pacientes do sexo feminino sem histórico de cirurgia palpebral prévia ou estrabismo. Após quatro meses, se a pálpebra do paciente persistisse com retração, uma cirurgia de desinserção de retratores era realizada. Os achados desse estudo corroboram a teoria de Malbouisson, Baccega e Cruz (2000). Eles concluíram que a descompressão inferomedial muda a posição do globo ocular, deslocando-o para baixo. Esse deslocamento aumentava a curvatura da pálpebra inferior e diminuía a da pálpebra superior, resultando em um contorno mais plano.

Na prática clínica, é comum a utilização de medidas da MRD (*margin reflex distance*) para avaliação da fenda palpebral. A MRD é a distância vertical entre a margem palpebral e o reflexo corneano induzido pela fixação de uma fonte de luz na posição primária do olhar (MURCHISON; SIRES; JIAN-AMADI, 2009). Essa grandeza é denominada MRD_1, se for em relação à pálpebra superior, e MRD_2 se inferior (Figura 2).

Figura 2 - MRD (*margin reflex distance*), MRD1 (superior), MRD2 (inferior)

A avaliação do contorno palpebral é importante em oculoplástica. Ele pode ser definido subjetivamente como suave (BERKE, 1945). A quantificação do contorno palpebral não é fácil. Cruz *et al.* (1998) realizaram um estudo de processamento digital de contorno palpebral em pacientes com OG e ptose. Os autores observaram que nos indivíduos normais, utilizados como controles, as curvaturas eram bem descritas por um polinômio de 2º e a MRD_1 era, em média, de 3,56 mm, com variação de 2,11 a 5,53 mm.

Murchison, Sires e Jian-Amadi (2009) estudaram as medidas de MRD_1 em indivíduos normais de diferentes etnias. Foram considerados sujeitos de descendência europeia, asiáticos, afrodescendentes e latinos. Os autores concluíram que os maiores valores de MRD_1 (média de 5,1 mm, DP 0,8) eram encontrados no primeiro grupo (europeus), e que os asiáticos tinham a menor média, com valor de 3,8 mm (1,1 DP). Não houve diferença significativa entre sexos nos grupos étnicos avaliados, concluindo-se que a determinação da normalidade do contorno palpebral deve ser individualizada e levar em consideração etnia, sexo, idade e expectativa do paciente.

Outro importante aspecto da fenda palpebral é sua obliquidade. Esse parâmetro aponta para a posição relativa do canto medial em relação ao canto lateral da fenda palpebral. Diferente da MRD_1, parece ser intuitivo que orientação da fenda esteja intrinsicamente relacionada às diferentes etnias. Hanada *et al.* (2001) estudaram a obliquidade da fenda palpebral em três diferentes grupos étnicos: brasileiros, japoneses e índios (localizados acima da bacia do Rio Negro, no Estado do Amazonas) por meio de fotografias frontais em posição primária do olhar. Foi utilizado um *software* para mensurar o ângulo formado entre os cantos medial e lateral da fenda. Não houve diferença significativa entre o grupo indígena e o grupo de japoneses. O grupo de japoneses apresentou angulação com média de 9,39 (2,39 DP) e o grupo de índios angulação de 9,64 (2,51 DP). Já o grupo de brasileiros obteve média de 4,31 (2,39 DP), significativamente diferente dos outros dois outros grupos. Os autores salientam que a orientação negativa da fenda (inclinação para baixo) não foi encontrada em nenhum indivíduo avaliado, podendo ser considerada uma variação anormal da morfologia.

Em resumo, é de suma importância conhecer os aspectos de normalidade relacionados à fenda palpebral, pois só assim é possível realizar uma avaliação criteriosa dos pacientes. A correção cirúrgica de pálpebras fora do padrão de normalidade deve levar em conta não apenas a MRD_1, mas também a angulação da fenda e curvatura do contorno palpebral.

1.2 Orbitopatia de Graves

A primeira vez que se teve notícia da descrição dessa doença na literatura data do século 12 quando Al Jurjani, um médico persa que vivia em Gorgan, Irã, escreveu textos médicos intitulados “Treasury of the King Khwarazm” descrevendo casos de exoftalmia e bócio (BURCH; WARTOFSKY, 1993) Entretanto, ele relacionou erroneamente esses sinais ao aneurisma. Séculos mais tarde, em 1786, Caleb Hillier Parry, observou novamente esta díade, no entanto a série de casos foi publicada apenas postumamente em 1825 (FORD, 1964). Dez anos depois, em 1835, o médico irlandês James Robert Graves fez novamente essa associação entre bócio e exoftalmia. Em sua palestra “Newly Observed Affection of the Thyroid Gland in Females”, Graves descreve três pacientes com bócio e palpitações. Uma quarta paciente, avaliada por seu colega Sir William Stokes, era uma paciente de vinte anos que exibia bócio, palpitações e exoftalmia; sinais que, a princípio, foram atribuídos à histeria. Discorreu então acerca dos olhos da paciente “...os globos oculares estavam visivelmente aumentados, a tal ponto que as pálpebras não conseguiam fechar durante o sono e ao tentar fechar o olho. Quando os olhos estavam abertos, o branco dos olhos podia ser visto na amplitude de várias linhas ao redor de toda a córnea.” Essa descrição evidencia dois sinais fundamentais da orbitopatia de Graves: proptose ou exoftalmia e retração palpebral (Figura 3) (WHITEHEAD, 1969).

Figura 3 - Paciente apresentando proptose e retração palpebral

Atualmente, sabe-se que a OG é uma doença autoimune e é a manifestação extratireoideana mais comum da doença de Graves. Essa doença pode causar, além da exoftalmia e retração palpebral, diplopia, estrabismo, ceratopatia e neuropatia óptica compressiva, configurando-se como uma condição, muitas vezes, incapacitante. Geralmente, está associada ao hipertireoidismo, embora em 7-8% dos casos a função tireoidiana seja normal ou mesmo diminuída por hipotireoidismo crônico (BARTALENA; FATOURECHI, 2014).

A prevalência de OG tem sido estimada em 8.97\ 10 000, o que está acima do que se considera como uma doença rara, nesse caso, menos que 5\10 000. Aproximadamente 30 a 50% dos pacientes com doença de Graves apresentam GO (PERROS *et al.,* 2017).

Em uma revisão de Bartalena e Tanda (2022), os autores chamam atenção para o fato de que o número de pacientes referenciados ao serviço terciário do Grupo Europeu de Orbitopatia de Graves (EUGOGO), em decorrência da OG, foi menor em 2012 do que em 2000. Atribuem esse fato ao diagnóstico e tratamento precoce do hipertireoidismo e da OG, bem como redução do tabagismo e suplementação de micronutrientes.

A patogênese da OG está relacionada à quebra de tolerância ao TSHR (receptor de TSH [Hormônio estimulador da tireoide]). No caso, epítopos de TSHR são reconhecidos como "não-*self*" por células apresentadoras de antígeno e células B que ativam linfócitos T auxiliares (*T helpe*r, Th) *naive*.

As células Th se diferenciam em diferentes subconjuntos, incluindo células Th1 produtoras de interferon gama (IFN-γ), células Th2 produtoras de interleucina (IL-4) e células Th17 produtoras de IL-17A. Essas citocinas, juntamente com autoanticorpos produzidos por plasmócitos derivados de células B autorreativas, estimulam os fibroblastos orbitários (FO) CD34+, iniciando respostas inflamatórias na órbita. O IFN-γ é citotóxico, a IL-4 auxilia na expansão das células B e na troca de classes de autoanticorpos e a IL-17A é pró-inflamatória e pró-fibrótica. Enquanto isso, fibrócitos periféricos infiltram tecidos orbitários e fazem a transição para FOs CD34+. Após a estimulação de IFN-γ e IL-17A, as células CD34+ não apenas produzem quimiocinas de forma robusta, mas também secretam grande quantidade de citocinas, como IL-1b e prostaglandina E2, que exacerbam a inflamação orbitária. Por fim, OFs CD34+ sintetizam ácido hialurônico e se diferenciam em adipócitos ou miofibroblastos que causam remodelação do tecido orbitário (FANG *et al.,* 2021).

Existem alguns fatores de risco associados à OG, alguns modificáveis e exógenos, outros endógenos (BARTALENA *et al.* , 2020). Possivelmente, o fator de risco mais conhecido e citado seja o tabagismo. Evidências apontam que pacientes fumantes além de terem maior probabilidade de desenvolvimento de OG quando têm mais chances de apresentarem as formas severas da doença. O tratamento em pessoas que fumam costuma ter resultados mais lentos e menos eficazes do que em pacientes não fumantes (BARTALENA *et al.,* 1989, 1998a; PRUMMEL; WIERSINGA, 1993).

O papel da disfunção tireoideana como fator de risco é controverso. Observou-se maior proporção de pacientes com formas severas de OG entre aqueles com função desregulada da tireoide do que naqueles com melhor controle hormonal (PRUMMEL *et al*., 1990). Entretanto, um número substancial de pacientes com hipertireoidismo não desenvolve a orbitopatia, e a doença ocular aparece em cerca de 5% de pacientes eutireoideos. Além disso, há estudos mostrando que o controle do hipertireoidismo não muda o curso da orbitopatia (BARTALENA *et al.,* 2020; PIANTANIDA *et al.,* 2013). Por fim, alguns outros fatores como, hipercolesterolemia, estresse oxidativo e aumento dos tílulos de anticorpo anti-TSHR (TRAB) também estão associados à progressão da doença (BARTALENA *et al.,* 1998b; BARTALENA; PIANTANIDA; LAI, 2003; HOU T-Y 2021; KHOO *et al*., 1999; LYTTON *et al.,* 2010; PRUMMEL *et al*., 1989; SABINI *et al.,* 2018; STEIN *et al.,* 2015; TALLSTEDT *et al.,* 1992; TRAISK *et al.,* 2009).

O diagnóstico precoce da OG é fundamental para controle dos fatores de risco modificáveis e início precoce do tratamento. As características clínicas mais comuns da OG são retração da pálpebra superior, proptose, edema e eritema dos tecidos periorbitários e da conjuntiva. Aproximadamente 3 a 5% dos pacientes com OG apresentam a forma severa da doença, com neuropatia óptica, dor intensa, ceratite de exposição, estrabismo, diplopia entre outros (WIERSINGA; BARTALENA, 2002). Entretanto, o acometimento ocular subclínico é o mais comum, em cerca de 70% dos pacientes. O diagnóstico nesses pacientes com sintomas mais leves é mais difícil sendo, muitas vezes, necessário exame de imagem para revelar algum aumento da musculatura extraocular ou aumento de tecido adiposo na órbita (ENZMANN; DONALDSON; KRISS, 1979).

A história natural da doença frequentemente inicia-se com uma fase inflamatória leve, com ativação inicial da cascata imunológica na órbita evoluindo até a doença atingir um platô. Após esse período, a doença entra em remissão até se tornar inativa. No período de inatividade ocorrem mudanças fibróticas na órbita (BARTALENA; PINCHERA; MARCOCCI, 2000). No entanto, esse padrão evolutivo nem sempre é observado e muitos pacientes não entram em remição e outros desenvolvem a orbitopatia sem sinais clínicos de atividade inflamatória (UDDIN; RUBINSTEIN; HAMED-AZZAM, 2018; UGRADAR; ROOTMAN, 2019).

As principais características da OG a serem consideradas para proposta de tratamento são: atividade da doença e a gravidade das manifestações clínicas (BARTALENA; TANDA, 2022). Alguns métodos de avaliação de atividade e severidade da doença foram propostos ao longo dos anos, entretanto, atualmente, dois sistemas classificatórios se destacam na avaliação clínica da doença: *Clinical Activity Score* (CAS) e VISA.

Mourits *et al*. (1989) descreveram o CAS. Esse *score* faz uma avaliação binária dos sinais clássicos de inflamação aguda (dor, hiperemia, edema e piora da visão); foi modificado em 1997 e a pontuação atribuída a cada critério incluído nesse sistema classificatório aponta objetivamente se o paciente está em fase ativa ou quiescente da doença (MOURITS *et al.,* 1989*,* 1997)

O sistema VISA foi desenvolvido por Dolman e Rootman (2006). É baseado em sintomas e sinais, avaliando quatro parâmetros de gravidade: V (visão); I (inflamação/congestão); S (estrabismo/restrição de motilidade); e A (aparência/exposição). Cada critério é classificado de forma independente. A pontuação final indica o *status* da doença e quanto maior o *score* apresentado mais agressivo o tratamento a ser empregado.

O manejo da OG inicia-se com o controle dos fatores de risco, como cessar tabaco, controle de hipercolesterolemia, administração de corticoide após iodo radioativo e colírio lubrificante para reduzir sensação de olho seco. Além do controle das variáveis que contribuem para evolução da OG existem duas frentes de tratamento: clínica e cirúrgica. O tratamento clínico só atua na fase inflamatória da doença, já que as sequelas da orbitopatia só são corrigidas cirurgicamente.

1.3 Retração palpebral

A retração palpebral é o critério maior para diagnóstico da OG. Mais de 90 % dos pacientes com a doença apresentam esse sinal (BARTLEY; GORMAN, 1995; DAY, 1959).

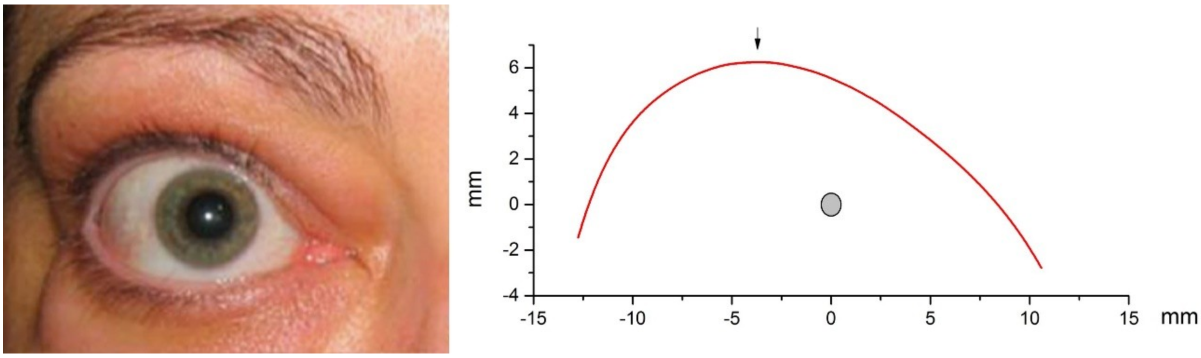
Em sua tese para a Sociedade Americana de Oftalmologia, Frueh foi o primeiro a realizar medidas da distância da pupila à margem palpebral em sujeitos normais. Em sua análise, concluiu que a média da distância da pupila à margem palpebral superior nesses indivíduos era de 3,5 mm com desvio padrão (DP) de 0,9 (Frueh, 1984; VAN DEN BOSCH; LEENDERS; MULDER, 1999).

Em uma revisão de literatura realizada por Cruz *et al*. (2013) sobre retração palpebral em pacientes com OG, os autores fazem interessante observação acerca dos valores encontrados por Frueh:

> Supondo que os valores médios e DP dessas medidas derivam de uma distribuição normal, apenas 2,25% dos pacientes normais têm pálpebras superiores acima da média de 2 DP (3,5 +\- 1,8), ou 5,3 mm acima da pupila. Dado que o diâmetro vertical da córnea é em média 11 mm, uma distância de 5,3 mm entre pupila e margem da pálpebra superior está aproximadamente no limite superior do limbo. Portanto, é aceitável considerar as pálpebras sob o limbo ou acima do limbo como estando retraídas (BARTLEY *et al.,* 1996; CRUZ *et al.,* 2013; SMALL, 1988).

No século XIX, o médico inglês John Dalrymple foi o primeiro a fazer a distinção entre proptose e retração palpebral. Atribuiu uma possível hiperatividade do músculo elevador da pálpebra superior (MEPS) como evento responsável pela retração palpebral (JAMES, 1926). Essa teoria ainda é utilizada para explicar esse sinal. Corroborando essa observação, Small (1988) realizou um experimento comparando a composição do MEPS em pacientes com Graves e indivíduos controle, mostrando que as fibras musculares em pacientes com OG estavam mais largas, quando comparadas com os controles. Entretanto, uma única medida não consegue exprimir a morfologia da retração e Waller (1982) já chamava atenção para esse fato fazendo alusão a T. J. Kirby, que em 1986 cunhou e expressão *Flare* Temporal em comunicação oral. Este termo faz referência ao aumento da retração palpebral na porção lateral da pálpebra, deslocando o pico do contorno da pálpebra superior lateralmente e aumentando a área temporal da fissura palpebral (Figura 4).

Figura 4 - *Flare* temporal demonstrado graficamente



Essa característica deve ser levada em consideração ao realizar uma cirurgia para correção da posição da pálpebra superior em pacientes com OG. O estado de hiperatividade do MEPS e, portanto, sua contração possivelmente justifica esse fenômeno, já que em indivíduos normais a retração palpebral voluntária induz o *FL* (CRUZ *et al.,* 1998; VAN DEN BOSCH; LEENDERS; MULDER, 1999).

Existem ao menos três teorias principais para explicar a etiologia da retração da pálpebra superior em pacientes com OG. A primeira, citada por John Dalrymple, versa sobre a hiperatividade do MEPS. Essa teoria é bastante citada na literatura (COCKERHAM *et al.,* 2002; ESSER; ECKSTEIN, 1999; GOPINATH *et al.,* 2007; GROVE, 1981; GUIMARAES; CRUZ, 1995; HAMED; LESSNER, 1994; HARRISON; McLOON, 2002; HARVEY; ANDERSON, 1981; HEDIN, 1988; LEWALLEN, 1958; MORAN, 1956; OHNISHI *et al.*, 1993; PIGGOT; NIAZI; HODGKINSON, 1995; PUTTERMAN; URIST, 1972; SMITH; LISMAN, 1981).

Existe um componente inervacional que favorece essa explicação. O músculo reto superior apresenta a mesma inervação do MEPS, assim, devido à restrição causada pelo reto inferior, o indivíduo, na tentativa de manter o olhar em posição primária, teria que utilizar o músculo reto superior ativando o complexo superior como um todo.

A segunda teoria para explicar a retração palpebral em pacientes com OG seria a hiperatividade do músculo de Müller, relacionada à atividade simpatomimética dos hormônios tireoidianos (BEN SIMON *et al.,* 2005; CEISLER *et al.* 1995; CHALFIN; PUTTERMAN, 1979; COCKERHAM *et al.,* 2002; COLLA; SEYNAEVE; DRALANDS, 1993; DIXON, 1982; ESMAELI-GUTSTEIN *et al.,* 1999; ESSER; ECKSTEIN, 1999; FRUEH; MUSCH; GARBER, 1986; GUIMARAES; CRUZ 1995; HAMADA *et al.,* 2000; HAMED; LESSNER, 1994; HARRISON; McLOON, 2002; HARVEY; ANDERSON, 1981; HEDIN, 1988; OHNISHI *et al.,* 1993; PIGGOT; NIAZI; HODGKINSON, 1995; PUTTERMAN; URIST, 1972; SMITH; LISMAN, 1981).

Por fim, a terceira explicação estaria relacionada ao efeito cicatricial e restritivo sob o MEPS. Os componentes elásticos dos retratores da pálpebra superior sofreriam um processo de inflamação culminando em fibrose. Imagens de cortes sagitais de ressonância magnética evidenciam aumento da espessura do MEPS em indivíduos com OG dando força a esta suposição (BEYER-MACHULE, 1989; DIXON, 1982; GROVE, 1981; PUTTERMAN; URIST, 1972; SMALL, 1988; SMITH; LISMAN, 1981).

A literatura ainda cita a proptose como fator contribuinte da retração palpebral. Embora essa teoria seja mais fraca quando comparada às três principais propostas, ela postula que o aumento extremo da proptose aumentaria a retração palpebral mecanicamente (CEISLER *et al.,* 1995; COLLA; SEYNAEVE; DRALANDS, 1993; FRUEH; MUSCH; GARBER, 1986; HAMADA *et al.,* 2000; HEDIN, 1988; SMITH; LISMAN, 1981).

1.4 Descompressão orbitária

A história da descompressão orbitária é bem conhecida e objeto de uma excelente revisão realizada por Alper (1995), fonte da maioria das informações históricas da cirurgia em tela. Em 1889, Kroenlein, um célebre cirurgião suíço, idealizou uma operação para remoção de um cisto dermoide orbitário por uma abertura na parede lateral da órbita. Sua técnica, no entanto, resultou em uma cicatriz não estética, pois a orientação da incisão era perpendicular às linhas de força de Langer da fossa temporal. O objetivo de Kroenlein era a exérese de lesão orbitária, ou seja, ele não idealizou a técnica para redução de proptose em pacientes com OG, mas foi o primeiro a realizar uma orbitotomia com remoção óssea. Em 1890, Julius Dollinger, de Budapeste, foi o primeiro cirurgião a, de fato, descomprimir a órbita de pacientes com proptose em decorrência da OG. Entretanto, utilizou uma incisão diferente da de Kroenlein, oblíqua alta estendendo-se de cima da sobrancelha lateral até o tragus. Essa foi a primeira descompressão bem-sucedida de órbita, permitindo que o conteúdo orbitário ocupasse espaço na fossa inferotemporal. Em 1929, Oskar Hirsch descreveu a remoção do assoalho orbitário e dois anos depois, o neurocirurgião americano Howard C. Naffziger relatou uma descompressão superior em que o conteúdo da órbita ocuparia parte da fossa craniana anterior. Por fim, a parede medial foi removida pela primeira vez, após etmoidectomia, por Kistner, em 1939 (ALPER, 1995).

As indicações para a cirurgia também mudaram ao longo do tempo. Classicamente, a cirurgia era realizada apenas em pacientes que apresentavam neuropatia óptica e/ou exposição extrema da córnea (DESANTO; GORMAN, 1973; GORMAN *et al.*, 1974; MAcCARTY *et al.*, 1970; WALSH; OGURA, 1957). Isso mudou na década de 1990, quando o procedimento passou a ser realizado também com objetivos estéticos (LYONS; ROOTMAN, 1994). Na maioria das vezes, a cirurgia é realizada durante o estágio de inatividade da doença. Entretanto, em algumas situações de perda visual iminente, como neuropatia óptica e risco de perfuração ocular, a descompressão é realizada na fase ativa. Atualmente, as indicações são amplas e a técnica individualizada para cada caso. As indicações incluem proptose, dor/desconforto crônico, congestão e exposição da córnea (BAHN; BARTLEY; GORMAN, 1992; ECKSTEIN; SCHITTKOWSKI; ESSER, 2012; EING; ABBUD; VELASCO E CRUZ, 2012; RUBIN *et al.*, 1998). Seja qual for a indicação, a reabilitação cirúrgica do paciente com OG tende a priorizar a descompressão da órbita por razões práticas e teóricas, como descrito por Shorr em meados da década de 1980 (SHORR; SEIFF, 1986). O paradigma clássico sugere que a descompressão seja o primeiro procedimento realizado, pois pode afetar medições do estrabismo. Posterior à descompressão, a cirurgia para correção da posição palpebral deve ser realizada e, por fim, a cirurgia para correção do estrabismo (BEN SIMON *et al.*, 2005; FICHTER; KRENTZ; GUTHOFF, 2013; LAGREZE; GERLING; STAUBACH, 2005; SANTOS DE SOUZA LIMA *et al.*, 2011). Alguns autores discordam desse paradigma, sugerindo que há uma mudança mínima na posição palpebral com a descompressão e que as cirurgias de retração palpebral e descompressão da órbita deveriam ser realizadas simultaneamente, a fim de encurtar intervalos de reabilitação (BEN SIMON *et al.*, 2005).

2. Objetivos

O objetivo do presente estudo foi observar a influência da cirurgia descompressiva de órbitas na morfologia da fenda palpebral de pacientes com orbitopatia de Graves. O estudo foi realizado em quatro fases consubstanciadas em publicações:

Fase 1 - Revisão sistemática da literatura sobre a descompressão lateral profunda.

Fase 2- Definição quantitativa do sinal do FL;

Fase 3- Efeito da descompressão da descompressão orbitária no FL;

Fase 4- Efeito da descompressão lateral sem reposição do rebordo lateral na morfologia da fenda palpebral.

3. Publicações Resultantes do Estudo

ARTIGO 1

Cruz AAV, Equiterio BSN, Cunha BSA, Caetano FB, Souza RL. **Deep lateral orbital decompression for Graves orbitopathy: a systematic review**. Int Ophthalmol. 2021;41(5):1929-1947.

Int Ophthalmol (2021) 41:1929–1947
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REVIEW

Deep lateral orbital decompression for Graves orbitopathy: a systematic review

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Abstract
Purpose To systematically review the literature on the deep lateral orbital decompression (DLD).
Methods The authors searched the MEDLINE, Lilac, Scopus, and EMBASE databases for all articles in English, Spanish, and French that used as keywords the terms orbital decompression and lateral wall. Two articles in German were also included. Data retrieved included the number of patients and orbits operated, types of the approach employed, exophthalmometric and horizontal eye position changes, and complications. The 95% confidence intervals (CI) of the mean Hertel changes induced by the surgery were calculated from series with 15 or more data.
Results Of the 204 publications initially retrieved, 131 were included. Detailed surgical techniques were analyzed from 59 articles representing 4559 procedures of 2705 patients. In 45.8% of the reports, the orbits were decompressed ab-interno. Ab-externo and rim-off techniques were used in 25.4% and 28.8% of the orbits, respectively. Mean and 95% CI intervals of Hertel changes, pooled from 15 articles, indicate that the effect of the surgery is not related to the technique and ranges from 2.5 to 4.5 mm. The rate of new onset of diplopia varied from zero to 8.6%. Several complications have been reported including dry eye, oscillopsia, temporal howling, lateral rectus damage, and bleeding. Unilateral amaurosis and subdural hematoma have been described in only one patients each.
Conclusions The low rate of new-onset diplopia is the main benefit of DLD. Prospective studies are needed to compare the rate of complications induced by the 3 main surgical techniques used.

Keywords Orbital surgery · Orbital decompression · Deep lateral decompression · Graves orbitopathy · Graves disease

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Introduction

The extended or deep lateral orbital decompression (DLD) is a procedure that expands the orbit by removing bone from the orbital plate of the greater sphenoid wing. This large thick diploic bony area lies posterior to the globe and, when removed, allows a significant posterior displacement of the globe [1]. Although DLD is not a new procedure, it has been recently used by many surgeons as a primary option for reducing the proptosis induced by Graves orbitopathy. A 2016 survey among the members of the American Society of Ophthalmic Plastic and Reconstructive Surgery revealed that almost half (45.7%) of the physicians operate lateral wall as an initial procedure in the combination with medial wall (39.5%) or a single wall (6.2%) [2]. The same trend was observed in a 2019 survey. Most respondents (54.2%) performed lateral wall decompression as their initial procedure, and 53.8% of these preferred lateral and medial decompression as a two-walled procedure [3]. The popularity of the DLD represents a tremendous shift of orbital decompression preferences. A similar survey showed that in 1985 the vast majority of the surgeons (75%) were using the antral-ethmoidal method to decompress the orbit. The lateral wall was decompressed by only 2.87% of the surgeons surveyed [4].

In this article, we review the literature on DLD including its historical background, technical aspects of the many approaches used to expose and remove bone from the great sphenoid wing, the effects of the surgery on the eye position, and complications.

Methods

The authors searched the MEDLINE, Lilac, Scopus, and EMBASE databases for all articles in English, Spanish, French, and German that used the terms orbital decompression and lateral wall in any field. The only exclusion criterium was the lack of a detailed surgical description of the lateral wall decompression. Studies on the anatomy of the sphenoid wing portion of the lateral wall and relevant historical articles on lateral wall decompression were also included. The data retrieved included the number of patients and orbits operated, types of the approach employed, exophthalmometric and horizontal eye position changes, lateral canthus and temporal fossa abnormalities, and other complications. The 95% confidence interval of the mean eye positional changes induced by the surgery was calculated for case series involving 15 or more operated orbits. In the case of sequential publications from the same service, we analyzed the article with the greater number of data.

Results

As shown in the flow diagram displayed in Fig. 1 the search yielded 204 articles. After a review by the senior author (Cruz), 73 articles were excluded due to lack of surgical information. The remaining 127 articles [1–127] were divided into 4 categories: (a) historical background [2–6, 8, 16, 17, 26–28, 34, 36, 40, 41, 45, 51, 53, 55, 58, 60, 61, 67, 69, 70, 73, 74, 85, 89, 91, 94–96, 99, 100, 106, 107, 111, 114], (b) anatomic studies [12, 19, 48, 49, 52, 57, 59, 62–64, 90, 104, 126], (c) surgical reports with significant quantitative data [14, 15, 21, 31, 44, 47, 57, 66, 71, 76, 81, 87, 102, 108, 115], and (d) articles on surgical descriptions or complications [1, 7, 9–11, 13, 22–25, 29, 30, 32, 33, 35, 37–39, 43, 46, 50, 56, 65, 68, 78, 79, 83, 86, 93, 97, 98, 101, 103, 110, 116–123, 125, 127].

Historical background

Lateral orbital decompression (DLD) is not a new procedure. Since 1911, when Dollinger decompressed the right orbit of a single patient with severe Graves orbitopathy (GO) [27], the lateral approach was added to the surgical armamentarium used to alleviate the proptosis provoked by GO. A detailed description of the early lateral decompressions can be found in paper published by the Guyton in 1946 [40]. According to Guyton, lateral decompressions were performed in 1935 by Swift and in 1939 by Spaeth [40]. Although Leone has been quoted as the first to have extended the lateral wall decompression down to the greater wing of the sphenoid [28, 65], a careful examination of the literature shows that several surgeons were already removing portions of the sphenoid wing for orbital decompressions in the first decades of the last century.

The deep portion of the lateral wall was probably first completely removed in the pterional approach described by Henry Welti in 1943 [41]. This procedure led Moran in 1956 [73] and Knauer in 1957 [58] to develop the temporal fossa route in order to remove large portions of the sphenoid wing with a hammer, chisel, and rongeurs. Moran was even more explicit than Knauer by describing the curettage of the thick sphenoid cancellous bone, bleeding control with bone wax, and the danger of entering the skull through the sphenoid bone [73, 74]. Stallard recommended to expose the dura with a burr at the junction of the great sphenoid wing with the frontal bone and then to use this opening to remove the lateral wall [99]. Similar mentions of the great sphenoid wing in lateral decompressions can be found in several articles published during the 1960s and 1970s [5, 41, 60, 69, 94, 95, 107]. Preservation of the lateral orbital rim through the temporal fossa approach, by

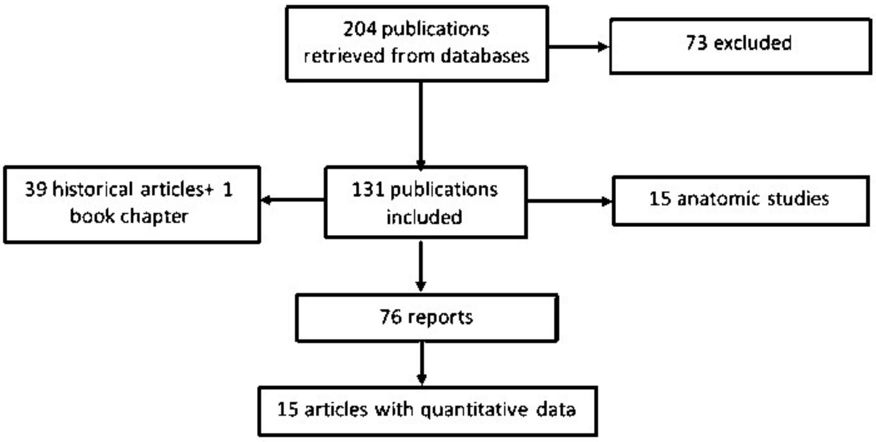

Fig. 1 Flow diagram. The database search yielded 204 articles. After review, 131 publications were included comprising of 40 articles on the history of deep lateral decompression, 15 anatomic studies, and 76 surgical reports

removing the posterolateral border of the zygomatic bone, was mentioned at that time by Knauer and Smith [58, 95].

In the 1980s, Kennerdell and Maroon described the radical four-wall orbital decompression which included the removal of the greater wing of sphenoid bone down to the dura of the temporal lobe [53, 54, 70]. During the same period Wirtschafter and Chu detailed the surgical anatomy of the temporal fossa for the external approach to lateral orbitotomy [111]. Despite a convincing report by Hurwitz that an extended lateral decompression to the sphenoid wing was an efficient procedure to be used to manage inadequate inferomedial decompressions [45], DLD was not regularly performed during the 1980s. The lack of enthusiasm about this procedure was probably due to the fact that decompressions were made to reverse optic neuropathy [4] and the surgeons feared to expose the middle cranial fossa. At that time avoiding the thick part of the sphenoid was the rule [34].

The interest in DLD was renewed when Leone, in 1989, published the results of 8 patients whose medial and the extended lateral walls were simultaneously decompressed, introducing the concept of balanced decompression [65]. The authors described in details their DLD technique which included the removal of the lateral orbital rim with a reciprocating saw, the use of a burr to address the great sphenoid wing, and the opening of the lateral periorbita to allow the fat to prolapse into the temporal fossa. The lateral rim was not replaced in any patient without causing cosmetic complications [65]. In 1992, using a cutting burr, Shore sculpted the frontal and sphenoid bones in the pterional area and lateral portion of the zygomatic bone in order to obtain additional space during the lateral decompressions [91].

If these two reports can be considered the rebirth of the DLD it was the work of Goldberg et al., published six years later in two articles, that spurred surgeons around the world to perform DLDs [1, 36]. For the first time the authors calculated, from computed tomographic scans, the bony volume of 3 areas of the lateral wall that could be removed during DLD: the inferolateral area formed mainly by the zygomatic bone, the thick trigone of the greater sphenoid wing, and the thick portion of the lesser wing of the sphenoid in the lacrimal fossa region. They also provided pre- and postoperative Hertel data about 13 orbits operated through the upper lid crease [1].

From large to small. The reduction of the size of skin incisions

The introduction of the lateral decompression to treat the exophthalmos induced by Graves' orbitopathy has been often accredited to Krönlein [6, 106]. As pointed out by Moran [74] this is a historical mistake. Krönlein used a large (6–7 cm) curvilinear incision with this convexity centered 1 cm posterior to the lateral canthus to remove the lateral wall of patient who had a dermoid cyst. There is no mention of orbital decompression in his original report [17, 61].

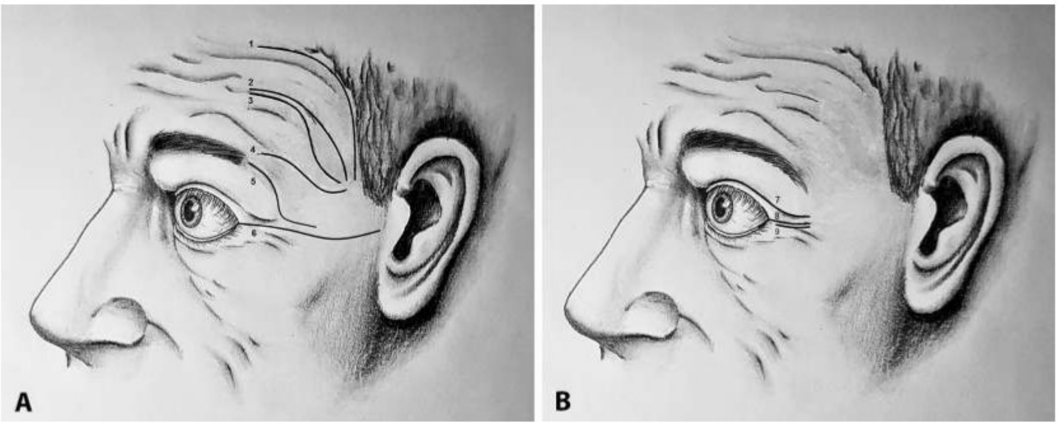

Fig. 2 Evolution of the incisions used to approach the lateral wall of the orbit. Early temporal fossa incisions: 1—hairline (Guyton 1946), 2 and 3—variations of Shugrue's technique (1939) used by Moran, 4— original Dollinger's approach (1911), 5—De Takats' (1932) later known as Stallard–Wright incision. Modern approaches: 6—eyelid crease, 7—lateral canthal, and 8—Berke

Dollinger, who was indeed the first to decompress the orbit, employed a completely different approach to the lateral wall with a high oblique incision extending from above the lateral brow to the tragus (Fig. 2a) [17, 27, 67]. Following Dollinger's initial report the first lateral decompressions were always performed through the temporal fossa without much care for the resulting scars. For instance, Moran used Shugrue's technique which was considered by Spaeth to be the most satisfactory for decompression [96]. In this procedure, the whole temporal fossa was exposed with curvilinear incision extending from the tragus to the lateral brow [73, 96]. Guyton tried to minimize the scars left by this type of procedure placing the incision posterior to the temporal hairline [40]. These large oblique or curvilinear incisions were replaced by S-shaped approaches closer to the lateral wall as first suggested by Kocher and employed in 1932 by De Takats [26]. During the 1960s Stallard and Wright popularized this incision which has been known since then as Stallard–Wright approach [99, 100] (Fig. 2a).

A radical departure from these high placed incisions started with the direct lateral canthal approach designed by Swift in 1937. Swift employed a 7-cm incision from the lateral canthus across the temporal fossa. He was probably the first to have removed and not replaced the rim in a lateral orbitotomy [17, 40]. The lateral approach to the orbit was improved by Berke in 1953 when he shortened the Swift's incision to 3–4 cm and released the superior and inferior crura of the lateral canthal tendon to expose the lateral rim (Fig. 2b) [16]. Although Berke contraindicated the removal of the lateral wall for the treatment of Graves orbitopathy, his incision was the starting point that reduced, even more, the access to the lateral orbital rim. Smaller straight incisions (2 cm) placed laterally to the canthus have been reported since the 1960s and 1970s (Fig. 2b) [17, 107].

In 1999 Harris introduced the lid crease approach to the lateral wall [42], an extremely cosmetic and small incision that allows good exposure of the lateral wall (Fig. 2b). A variant of the lid crease incision was described by Nemet and Martin [75]. To increase the exposure of the lower half of the lateral orbital rim the authors add a small triangle to the end of the incision.

Anatomic studies of the lateral wall

The increasing popularity of DLD stimulated several authors to study the anatomy of the lateral wall in detail. The location and volume of the orbital portion of the sphenoid bone were measured on dried skulls [12], in cadaveric dissections [48, 49, 104], or by computed tomography [19, 59, 62–64, 90].

Segmentation of 3-dimensional CT scans of the lateral wall shows that the orbital portion of the greater sphenoid wing is a polyhedron whose shape can be approximated to that of a truncated pyramid or triangular prism [104] formed by a triangular base, one straight (orbital or medial) side, and 2 curved sides one facing the temporal fossa (lateral) and the other facing temporal lobe of the brain (intracranial or

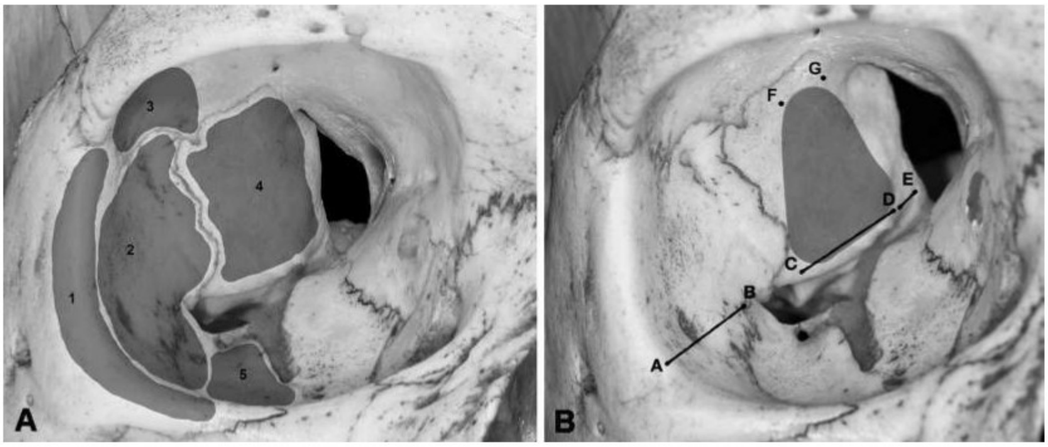

Fig. 3 **a** Areas of the lateral wall that can be removed: (1) lateral rim; (2) anterior portion of the lateral wall; (3) lacrimal fossa; (4) orbital portion of the greater sphenoid wing; (5) lateral portion of the floor; **b** linear measurements of the deep portion of the lateral wall Beden [12]. AB = distance between the lateral rim and the inferior orbital fissure, CD—width of the base of the sphenoid trigone, DE—distance between the base of the trigone and the superior orbital fissure. FG—width of narrowest portion of the trigone

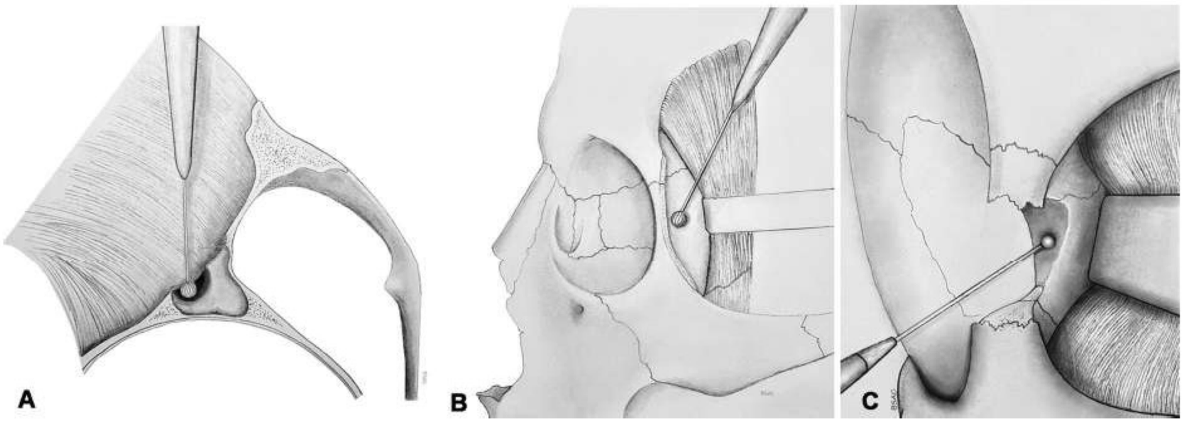

Fig. 4 Main approaches used to decompress the deep portion of the lateral wall of the orbit: **a** internal, **b** external, and **c** rim-off

posterior). It should be pointed out that the nomenclature of these bony surfaces is not standard. For instance, the orbital side of the sphenoid wing has been also referred to as "anterior" [90]. Although both the base and apex of the pyramid have a triangular shape, the base is larger than the apex that narrows toward the orbital roof. In axial CT slices, the deep lateral wall appears as a triangle, hence the denomination sphenoid trigone [1, 64].

Figure 3 shows the areas of the lateral wall that can be surgical removed and the linear measurements of the main parameters of the orbital projection of the great sphenoid wing obtained by Beden [12]. The mean ± SD values are: the distance between the rim and the inferior orbital fissure = 14.5 mm ± 1.87, width of the base of the sphenoid bone = 13.0 ± 2.28, the distance between the end of the base of the sphenoid bone and the superior orbital fissure = 5.8 mm ± 1.60, and the width of the narrowest portion of the deep lateral wall = 5.2 mm ± 5.0 SD.

The posterior side of the trigone, which marks the transition of the wall to the middle intracranial fossa, was studied by Kakizaki et al. in 17 fresh cadavers/27 orbits [48]. At 8 mm above the inferior orbital rim, the mean distance between this important surgical landmark and the lateral orbital rim was about 33 mm.

There was no difference in the width between the right (17.6 mm) and left (17.3 mm) sides. The transition between the orbital roof and the superior border of the posterior side of the lateral wall was also studied in 13 cadavers/27 orbits [49]. The authors have stressed that there is no bone marrow at the junction of the orbital roof and superior border of the posterior wall of the lateral wall. In this area, only a thin cortical bone separates the orbit from the junction of the middle and anterior cranial fossae.

Bi- and tridimensional computed tomographic analyses [57, 59, 62, 90] have provided volumetric data of the sphenoid trigone [64] as well as other information such as the angulation of the lateral orbital rim [52]. The volume of the sphenoid trigone is important because theoretically, it is related to the amount of decompression that can be achieved. A study comparing the volume of the sphenoid trigone in normal males and females from 3 different racial backgrounds (White, Blacks, and Asians), revealed that the mean male volume was significantly larger than the mean female volume (1.71 ± 0.83 cm^3 vs. 1.35 ± 0.55 cm^3) [64]. No difference between races was found. One interesting finding of this study was the wide variability of the measurements between males and females of all races. The volume of the sphenoid trigone varied by a factor of 10.3 in white males and by a factor of 13.5 in white females [64].

Is the calculation of the volume of the sphenoid trigone a crucial measurement for predicting the effect of deep lateral orbital decompression? According to Kitaguchi et al. the answer is no. They have shown that the width of the trigone, defined as the distance between the posteromedial and posterolateral vertexes, is a significant positive predictor of proptosis reduction induced by the decompression [57]. It would be important to see whether their results are replicated with different types of patients because this evaluation, on a single axial slice transecting the horizontal recti and the optic nerve, is much easier and less time-consuming than performing volumetric analysis.

Contemporary surgical techniques

An analysis of 59 reports on deep lateral orbital decompression shows that a wide variety of surgical techniques for DLD have been reported (Table 1). [1,7,9–11,13–15,21–25,29–33,35,37–39,43,44,46,47, 50, 56, 57, 65, 66, 68, 71, 76, 78, 79, 81, 83, 86, 87, 89, 93, 97, 98, 101–103, 108, 110, 115–123, 125]. There are 2 reports from neurosurgeons on the transcranial route to decompress the lateral wall, either through the classic pterional approach [118] or through the resection of basofrontal bone flap [68]. Other uncommon procedures include lateralization of the lateral wall [93, 97, 119] or exposition of the wall with coronal [9, 37, 97, 123], brow [123], or temporal hairline incisions [38]. Understandably the vast majority of oculoplastic surgeons prefer more direct and inconspicuous incisions such as the lid crease [10,13–15,21,24,25,29,31–33,36,37,43,56,81,83,87,-89, 108, 110, 115, 116, 120, 122, 125], or the direct lateral canthal approach with [11, 44, 50, 57, 66, 93, 101–103, 117, 119, 121] or without cantholysis [7, 22, 23, 30, 47, 65, 71, 76, 78, 86, 98, 102].

The technical aspects related to removal of the sphenoid trigone are more important than the incisions employed to expose the lateral wall. Following Goldberg's original description [1] in 45.8% of the 59 reports the orbits were decompressed ab-interno, from the orbital side of the sphenoid trigone (Fig. 4a) [7, 10, 11, 29, 57, 66, 76, 79, 83, 87, 89, 103, 116]. Decompressions, ab-externo, from the temporal fossa, were employed in 25.4% of the reports [15,21–23,25,30,31,33,43,44,47,50,65,71,78,81,86,9-8, 101, 108, 115, 117, 121, 125]. As first stated by Chang and Piva [21] through this route the operating field is much larger than with the internal approach and no pressure is exerted on the orbital contents. However, to reach the greater sphenoid wing through the temporal fossa it is necessary to reduce the dimensions of the zygomatic tubercle or to remove the rim. Some surgeons use either a burr, a saw, or an ultrasonic aspirator to thin the lower segment of the orbital rim (Fig. 4b) [21, 25, 30, 43, 47, 71, 108]. Finally, in 28.8% of the reports the surgeons preferred to remove the rim (the so-called rim-off technique (Fig. 4c)), from the frontal-zygomatic suture down to the zygomatic arch level, which is then restored [23, 50, 78, 81, 86, 98, 101, 121] or not [22, 31–33, 65, 115, 117] at the end of the procedure.

Whether based on internal or external approaches DLD does not require sophisticated instruments. Cutting burrs may initially be used to remove the bone from the sphenoid trigone, and 4-mm diamond burrs are employed once the cancellous part of the sphenoid wing is reached [21, 72]. However,

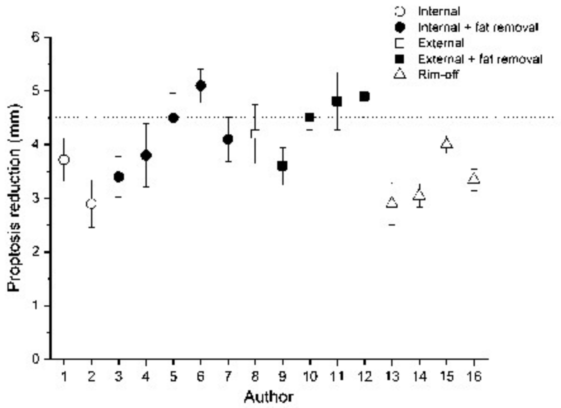

Fig. 5 Mean (95% CI) of proptosis reduction obtained from: 1 = Nguyen[76], 2 = Kitaguchi [57], 3 = Ben Simon [14], 4 = Liao [66], 5 = Sellarini/Franceschini [87], 6 = Takashi [102], 7 = Kitaguschi [57], 8 = Fitcher [115], 9 = Fitcher [31], 10 = Jefferis [47], 11 = Horn [44], 12 = Ueland [108], 13 = Chang [21], 14 = Metha [71], 15 = Bengoa-Gonzalez [15], 16 = Porrua-Tubio [81]

instruments such as ultrasonic aspirators have been proposed in order to increase the safety of the procedure [15, 22, 124]. With this type of device the bone is emulsified at a frequency that is different from the frequency capable of provoking soft tissue damage [124]. Although a direct comparison between two groups of patients decompressed with conventional burrs or ultrasonic aspirators showed no difference regarding surgical complications, ultrasonic bone removal might be a safe way to teach DLD [22]. Stereotactic navigation is another technique that can be used to help the surgeon to safely approach the posterior wall of the sphenoid trigone [72, 112]. As pointed out by Patel, once the surgeon has acquired enough experience with the anatomy of the lateral wall neuronavigators are not needed to perform the surgery.

Surgical effects

Proptosis reduction

The primary goal of the DLD is to reduce proptosis. The mean and the 95% CI values of Hertel changes obtained from 16 series with more than 20 orbits are plotted in Fig. 5. These results suggest that both the internal and external approaches yield similar results with a mean proptosis reduction ranging from 3.0 to 4.5 mm.

Fat prolapse into the temporal fossa and lateral rectus changes

Depending on the degree of orbital compliance different amounts of fat and the lateral rectus tissue prolapse into the new space created (Fig. 6), the lateral rectus displacement into the temporalis fossa and consequent deformation of its path was already noticed in 1985 when Hurwitz reported his first cases of DLD [46].

Horizontal eye displacement

We found only two studies suggesting that a small lateral displacement of the eye occurs when the lateral wall is removed [33, 102]. At 3 months after DLD with rim removal Fitcher et al. detected a mean 1.2 mm lateral displacement of the eye [33]. In the Takahashi's series with rim preservation, the lateral eye displacement was smaller with a mean value of 0.5 mm [102].

Complications

New-onset diplopia

Despite the gross changes in the lateral rectus path and dimensions [39], these effects have little influence on the postoperative eye balance. As shown in Table 2, 0 up to 8.6% of the patients who did not have strabismus preoperatively reported [14, 15, 21, 31, 44, 47, 66, 71, 81, 83, 87, 108] diplopia after DLD. In most of these reports, the actual deviation was not measured or even described. In some cases diplopia was recorded in extreme ductions.

Large esotropia deviations are not common after DLD and probably represent accidental damage to the lateral rectus muscle or the VI cranial nerve during bone removal [21]. To the best of our knowledge, this type of occurrence has been reported only once after an internal approach procedure [35].

Oscillopsia, Temporal hollowing, masticatory difficulty, and chemosis

Some complications are related to the approach used to perform the DLD. For instance, postoperative oscillopsia, temporal hollowing, and masticatory

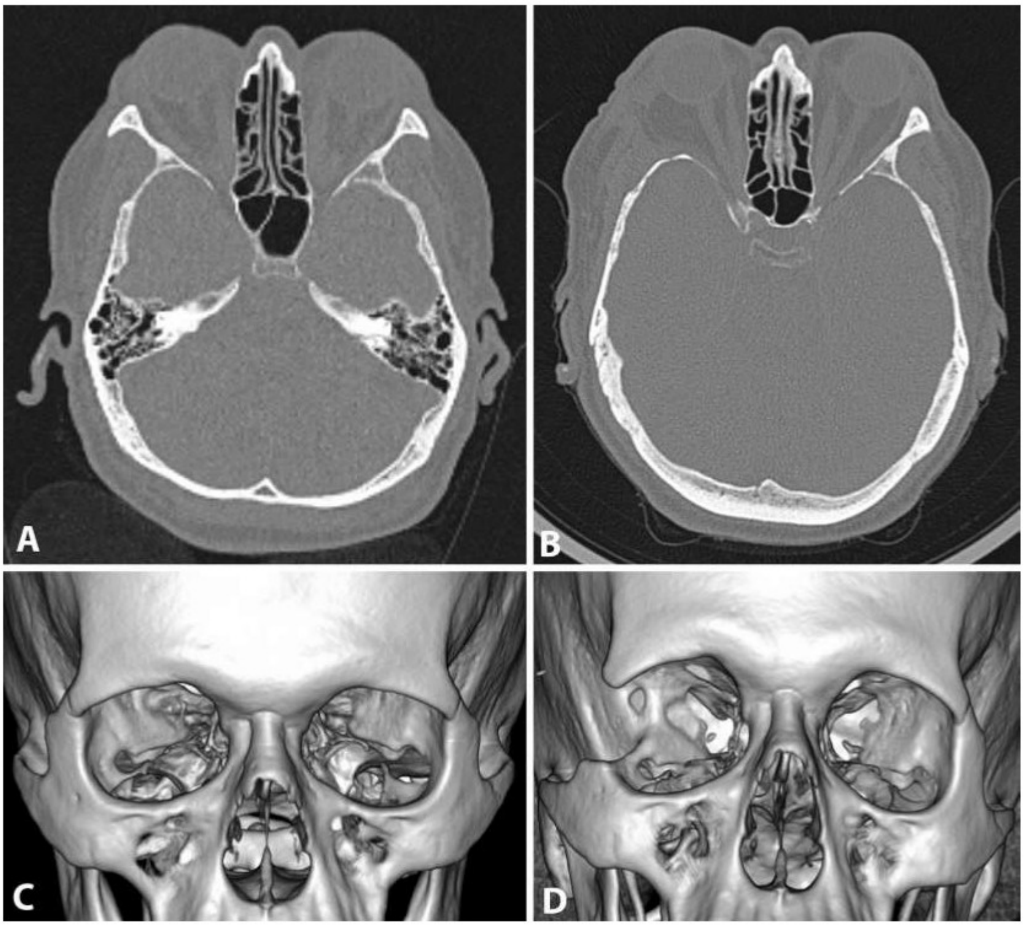

Fig. 6 Computed tomography of pre- (**a**, **c**) and post- (**b**, **d**) right rim-off deep lateral decompression. Top: bone window axial slices. Bottom: 3-D reconstruction

problems are associated with the external approach. Goldberg was the first to point out that oscillopsia with chewing was due to the contact between the temporalis muscle and the orbit and recommended that a thin shell of bone should be left over the temporalis muscle [1]. Protection of the orbital contents with a residual piece of bone is not possible with the external approach because the surgery is performed from the temporal fossa toward the orbit. The rate of oscillopsia with the different options used to deal with the lateral rim is quite variable (Table 3). Chang and Piva, who employed an aggressive external DLD in 33 patients, had no case of oscillopsia despite wide dural exposure [21]. Small rates of oscillopsia ranging from 0 to less than 10% have been reported with the rim spared or not [31, 50, 86, 125]. In contrast, in the only specific survey on postoperative oscillopsia, 34 out of 98 patients who underwent external DLD reported oscillopsia during chewing or walking. For 16 patients the problem continued for more than 2 years [30]. A recent study found that the occurrence of oscillopsia after DLD is greatly reduced when the medial wall is also removed [81].

Temporal hollowing and masticatory problems derive from temporalis muscle manipulation. Difficulty with mastication is considered to be a transitory minor problem that disappears spontaneously within 6 months after surgery [15, 50]. On the other hand temporalis muscle wasting may be serious enough to warrant surgical correction [92, 109]. Although as shown in Table 3 temporalis muscle atrophy has been found in procedures in which the rim is spared or

Table 1 Reports on deep lateral orbital decompression

Author	Patients/ orbits	Decompressions (orbits)				Surgical technique			
		Lateral only	Balanced	Lateral + Inferior	3 walls	Lateral Rim	Incision	Fat removal	Approach
Hurvitz [46]	NS/35	7	0	27	1	Removed with or without repositioning	Stallard	No	Rim-off
Leone [65]	8/12	0	12	0	0	Removed	Lateral	No	Rim-off
Goldberg [1]	7/13	13	20	0	0	Spared	Eyelid crease	No	Internal
Sheppard [89]	11/20	0	20	0	0	Spared	Eyelid crease	No	Internal
Paridaens [79]	19/35	0	2	0	33	Spared	Lateral cantholysis	No	Internal
Goldberg [37]	32\63	38	25	0	0	Spared	Coronal approach (8) Lid crease (30)	Yes	Internal
Ünal [110]	9/14	0	14	0	0	Spared	Eyelid crease	No	Internal
Linnet [68]	30/50	0	50	0	0	Spared	Transcranial	No	Internal
Korinth [118]	42/59	0	Lateral + roof	Spared	Transcranial	No	Pterional		
Kikawa [117]	23/39	9	21	0	9	Spared/removed	Lateral cantholysis	Yes	Internal/ Rim-off
Graham [119]	40/63	0	63	0	0	Lateralized	Lateral cantholysis	No	Rim-off
Ünal [120]	18/31	0	18	0	13	Spared	Eyelid crease	Yes	Internal
Vaseghi [116]	26/47	0	NS	NS	NS	Thinned	Eyelid crease	No	Internal
Ben Simon [14]	116/201	201	0	0	0	Spared	Eyelid crease	Yes	Internal
Fitcher [115]	23/31	31	0	0	0	Removed	Eyelid crease	Yes	Rim-off
Baldeschi [9]	15/30	0	0	0	30	Spared	Coronal	NS	External
Sellari-Franceschini [123]	140/276	0	276	0	0	Spared	Coronal/brow/ Lid crease		External
Bailey [121]	55/97	0	0	0	97	Removed and repositioned	Swing eyelid	No	Rim-off
Ben Simon [122]	96/158	158	0	0	0	Spared	Eyelid crease	Yes	Internal
Ben Simon [13]	11/19	19	0	0	0	Spared	Eyelid crease	Yes	Internal
Liao [66]	35/62	62	0	0	0	Spared	Swinging eyelid	Yes	Internal
Silver [93]	25/47	0	32	0	15	Lateralized	Lateral cantholysis	No	Internal/ External
Chang [21]	33/65	65	0	0	0	Thinned	Eyelid crease	No	External
Barkuysen [11]	7/14	0	0	0	14	Spared	Lateral cantholysis	No	Internal

Table 1 continued

Author	Patients/ orbits	Decompressions (orbits)				Surgical technique			
		Lateral only	Balanced	Lateral + Inferior	3 walls	Lateral Rim	Incision	Fat removal	Approach
Sellari-Franceschini [87]	39/72	72	0	0	0	Spared	Eyelid crease	Yes	Internal
Cho [22]	22/36	36	0	0	0	Removed (n = 18)	Lateral canthal	No	Rim-off
						Spared (n = 18)			Internal
Alsuhaibani [7]	20/38	0	38	0	0	Spared	Lateral canthus	No	Internal
Kakizaki [50]	32/47	24	23	0	0	11 Spared	Swinging eyelid	Yes	13 Rim-off
						13 Removed and repositioned			11 Internal
Metha [71]	17/21	21	0	0	0	Thinned	Lateral	No	External
Choe [23]	6/10	10	0	0	0	3 Removed and repositioned	Lateral	no	Rim-off
									7 Internal
						7 spared			
Fitcher [32]	100/148	148	0	0	0	Removed	Eyelid crease	No	Rim-off
Rocchi [83]	50/97	97	0	0	0	Spared	Eyelid crease	Yes	Internal
Fitcher [33]	18/30	30	0	0	0	Removed	Eyelid crease	Yes	Rim-off
Fayers [30]	79/128	76		NS	NS	Thinned	Lateral	No	External
Baril [10]	34/59	0	59	0	0	Spared	Eyelid crease	No	Internal
Nguyen [76]	69/108	108	0	0	0	Spared	Lateral	No	Internal
Takahashi [102]	78/156	94	44	0	0-	Spared	Lateral with or without cantholysis	Yes	Internal
Kim [56]	27/48	2	16		27	NS	Eyelid crease	Yes	NS
Fichter [31]	111/164	164	0	0	0	Removed	Eyelid crease	Yes	Rim-off
Takahshi [103]	90/171	171	0	0	0	Spared	Lateral (n = 49)	No	Internal
							Swinging eyelid (122)		
Sagiv [86]	112/186	0	89	0	97	79 Removed and repositioned	Lateral	No	Rim-off
						107 removed			
Ueland [108]	84/144	144	0	0	0	Thinned	Eyelid crease	No	External
Choi [24]	24/48	0	48	0	0	NS	Eyelid crease	No	NS
Hernandez-Garcia [43]	20/36	0	36	0	0	Thinned	Eyelid Crease	No	External

Table 1 continued

Author	Patients/ orbits	Decompressions (orbits)				Surgical technique			
		Lateral only	Balanced	Lateral + Inferior	3 walls	Lateral Rim	Incision	Fat removal	Approach
Sweeny [101]	19/33	22	11	0	0	Spared = 19 Removed and repositioned = 14	Swinging eyelid crease	No	Internal/ External
Ellis [29]	4/6	6	0	0	0	Spared	Eyelid crease	No	Internal
Gong [38]	38/41	0	41	0	0	Spared	Hairline approach	No	External
Spalthoff [97]	2/4	2 (*)	1	0	1	Lateralized	Coronal	Yes	External
Gupta [39]	48/75	0	75	0	0	Removed	NS	NS	NS
Jefferis [47]	55/93	61	2	0	11	Thickness reduction	Lateral	Yes	External
Golan [35]	2/2	2	0	0	0	Spared	Transconjunctival Eyelid crease	Yes Biopsy	Internal
Cubuk [25]	149/231	13	181	0	39	Thickness reduction	Eyelid crease	yes	External
Sthär [98]	174/318	0	318	0	0	Removed and repositioned	Lateral	Yes	Rim-off
Oeverhaus [78]	68/125	0	125	0	0	Removed and repositioned	Lateral	Yes	Rim-off
Zhang [125]	50/75	18	24	0	33	Removed = 52 Spared = 23	Eyelid crease	No	Rim-off External
Bengoa-Gonzalez [15]	35/58	58	0	0	0	Thinned	Eyelid crease triangular	N0	External
Horn [44]	127/195	195	0	0	0	Removed	Lateral cantholysis	Yes	Rim-off
Kitaguchi[57]	43/43	43	0	0	0	Preserved	Lateral	Yes/no	Internal
Porrúa-Tubío [81]	19/35	35	NS	NS	NS	Removed and repositioned	Eyelid crease	No	Rim-off

Table 2 New-onset diplopia after deep lateral orbital decompression

Author	Number of patients	Surgical approach	Fat removal	New-onset diplopia (%)
Ben Simon [14]	80	Internal	Yes	3.7
Liao [66]	33	Internal	Yes	5.7
Chang [21]	33	External	No	3.0
Sellari-Franceschini [87]	39	Internal	Yes	7.7 (extreme gaze)
Mehta [71]	16	External	No	0
Rocchi [83]	27	Internal	NS	0
Fitcher [31]	58	External	Yes	8.6
Ueland [108]	55	External	No	7.2
Jefferis [47]	35	External	NS	8.6
Bengoa-Gonzales [15]	22	External	No	0
Horn [44]	47	External	Yes	2.1
Porrúa-Tubio [81]	17	External	NS	5.9

removed. The only case series published about this problem consisted of patients who had undergone DLD with rim spared [92]. Interestingly out of 11 orbits with temporalis wasting 9 presented with dry eyes.

Persistent postoperative chemosis is rarely reported but can be a complication of the lid-swing approach. The mechanism of chemosis is not entirely understood, but it seems to be related to the disturbance of the lymphatic drainage of the conjunctiva [103].

Bleeding, blindness, and intracranial life-threatening complications

Intra- or postoperative bleeding is scarcely mentioned [87]. However, two surgeons have reported early postoperative hemorrhage requiring the patient to go back to the operating room on the same day for immediate revision and hemostasis [31, 117] and the only case of blindness was associated with an apical hematoma following an external approach [108]. Small dural tears are relatively common and usually do not provoke any problems [127]. However, depending on the intensity of the trauma subdural hemorrhage can be a life-threatening complication as reported by Jefferis et al. in one patient who underwent an internal DLD [47].

Discussion

The DLD is firmly established as an option in the armamentarium of procedures employed to manage the proptosis caused by Graves orbitopathy. Three different approaches are used by the vast majority of surgeons. Those who prefer not to deal with the temporalis muscle perform the surgery ab-interno sculpting the orbital plate of the greater sphenoid wing without removing the orbital rim [7, 10, 11, 29, 57, 66, 76, 79, 83, 87, 89, 103, 116]. The proponents of the external approach stress the wide exposure when the surgery is done from the temporal fossa toward the orbit [21, 47]. To reach the floor of the temporal fossa the lateral rim has to be thinned. The third approach is rim-off DLD. When the rim is removed the surgery can be done from above, medially or laterally facilitating the excision of the whole sphenoid trigone. No randomized studies are comparing these main different surgical options concerning the decompressive effect. However, as illustrated in Fig. 5 the data pooled from the literature strongly suggest that the decompressive effect obtained with DLD is not related to the type of approach used. Whether the surgery is performed by the internal or external route or with rim-off the average reduction in proptosis ranges from 2.5 to 4.5 mm.

Some complications are associated with technical details. In the external approach, a strong retraction

Table 3 Temple problems associated with deep lateral orbital decompression

Author	Number of patients/orbits	Lateral rim	Oscillopsia (%)	Masticatory difficulty (%)	Temporal hollowing (%)
Chang [21]	33/65	Spared	0	NS	7.7
Kakizaki [50]	32/47	Removed/Repositioned	0	100 (< 6 months)	N S
Fitcher [33]	18/30	Removed	NS	NS	16.6
Fayers [30]	98/163	Spared	35 < 1 yr 16 > 2 yr	NS	NS
Fitcher [31]	111/164	Removed	0.9	NS	1.2
Ueland [108]	84/144	Spared	29	NS	56
Sagiv [86]	112/186	Removed (n = 107)	5.6	NS	0
		Removed/ Repositioned (n = 79)	2.5	NS	0
Sweeney [101]	33/33	Spared (n = 14)	NS	NS	0
		Removed/ Repositioned (n = 19)	NS	NS	0
Bengoa-Gonzalez [15]	35/58	Spared	NS	28.5(< 6 months)	0
Zangh [125]	50/75	Spared (n = 23)	0	NS	0
		Removed (n = 52)	0	NS	5.8
Porrua-Tubio [81]	131/19 (lateral only, 112 2 or 3 walls	Removed/ Repositioned	Lateral = 26.3	NS	NS
			2 or 3 - walls = 1.8	NS	NS

needs to be applied over the temporalis muscle as shown in Fig. 2 of the manuscript by Fayers et al. [30]. Temporalis manipulation and not the absence of the lateral wall is believed to be the main factor in the pathogenesis of muscle atrophy and fibrosis with consequent postoperative howling [128] and masticatory problems. If the rim is removed, manipulation of the temporalis muscle is reduced and these complications seem to be avoided or at least diminished. Some authors believe that if the rim is not replaced, the surgical effect is enhanced [28]. There are no data to corroborate this theory. On the other hand, the plethora of harmful effects predicted when the rim is off, such as loss of canthal orientation and shape, increased lid retraction and lateral rectus imbalance [91], have not been found. Surprisingly the shape and function of the lateral canthus seem to be unaffected when the rim is permanently removed [28, 33, 86].

Even if the internal approach bypasses all the technical problems associated with temporalis manipulation, it has its drawbacks. Exposure is poorer and the risk of lateral rectus muscle damage and dural perforation is increased. As the sphenoid trigone is not completely removed, bony regrowth is a possibility that has already been documented [82].

Dry eye is a complication that has received less attention, but it can certainly occur. When the bone of the lacrimal fossa has removed, the orbital lobe of the lacrimal gland prolapses into the temporalis fossa. Does this contact between the gland and the muscle have any beneficial effects? Goldberg in his description of DLD considered the lacrimal fossa to be one of the main areas to be decompressed [1]. However, in the only series of temple complications associated with DLD with rim sparing, five patients presented with dry eyes. In one patient a prolapsed lacrimal gland was repositioned into the orbit [92]. Damage to the postganglionic parasympathetic innervation is another possibility. The secretory lacrimal fibers travel toward the lacrimal gland within the zygomaticotemporal nerve close to the lateral periorbita [126]. Excessive heat generated during the removal of the sphenoid trigone or direct lesion of the nerve during fat excision might be involved in the pathogenesis of dry eye after DLD.

Accidental entrance into the middle cranial fossa is usually limited to small dural tears and cerebrospinal fluid leaks that are managed with conservative treatment [127]. One of the advantages of the external or rim-off approaches is to allow wide exposure to managing dural tears. Besides, the adjacent temporal muscle provides vascularized tissue to easily seal any type of dural tears [21, 50, 101].

Serious bleeding although rare can complicate DLD. We found only a single paper that specifically discussed the sphenoid diploic veins as the origin of this potentially serious event [129]. As is the case for other bones of the skull, the marrow space of the thick portion of the greater sphenoid wing is filled with cancellous bone, also called diploe, which contains the diploic veins [130]. These vessels, which are the source of bleeding during DLD, are usually small. Nevertheless, as shown by Rafaelof et al. large vessels can exist connecting the sphenoid diploic veins to the anterior temporal diploic vein located in the pterional area [129]. Another source of bleeding is represented by temporal vessels connecting the infratemporal and temporal fossae to the orbit [131]. Hemorrhage from diploic veins is well controlled by bone wax that should always available in DLD. If not well-controlled blood can accumulate in the orbital apex and lead to vision loss. The apical hematoma was the factor that led to the only case of unilateral amaurosis after an external DLD [108]. Taking into consideration all decompressions reported in Table 3 only 0.02% of the DLD cases were associated with permanent vision loss.

In summary, despite its wide acceptance by orbital surgeons, DLD is performed in 3 different major ways: ab-interno, ab-externo, and with rim-off. The pros and contras of these different approaches have not been compared. The main characteristic of DLD is its minor effect on the oculomotor balance. However, a variety of complications have been published that deserve to be acknowledged and discussed with the patients.

Data availability All material used in the publication is storage and available to the journal.

Compliance with ethical standards

Conflict of interest The author declares that they have no conflict of interest.

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ARTIGO 2

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Lid Flare Measurement with Lateral Midpupil Distances

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ABSTRACT

Purpose: To assess the sensitivity and specificity of lateral midpupil lid distances for the detection of upper lid lateral flare.

Methods: Lateral lid flare was determined by unanimous agreement among six experienced oculoplastic surgeons in the grading of photographs obtained for patients with Graves orbitopathy (GO). Bézier lines were employed to extract the upper eyelid contours of the patients and a control group of age and sex matched subjects. Custom software was employed to determine 5 lateral midpupil eyelid distances. The sensitivity and specificity of each measurement in detecting lateral flare were estimated from receiver operating characteristic curves. The non-parametric Kruskal–Wallis one-way analysis of variance (ANOVA) with Dunn's posthoc test was used to compare the median values of the contour parameters between groups.

Results: The degree of agreement between judges evaluated with the Fleiss' Kappa test was relatively high ($K = 0.69, z = 16.6, p < .0001$). The raters classified 12 lids with lateral lid flare (LLF) and 7 without LLF in patients with GO. There was no agreement on the presence or absence of LLF in 11 lids. In all eyes, lateral midpupil lid distances diminished from the center of the eyelid towards the lateral canthus. Receiver operating characteristic analysis for the midpupil distances revealed that the fourth distance from the center demonstrated high sensitivity and specificity in detecting flare. At this location (2.5 mm medial to the lateral canthus) a midpupil distance equal to or greater than 60% of the margin reflex distance (MRD_1) indicated the presence of flare.

Conclusions: – A single measurement of a lateral midpupil eyelid distance 2.5 mm medial to the lateral canthus is a sensitive and specific measurement for the diagnosis of the LLF.

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Lid flare; lid contour; graves orbitopathy; lid retraction; beziér lines

Introduction

Following an oral communication from T.J. Kirby Jr in the early eighties, Waller was likely the first to coin the term lateral flare to designate the enhanced lateral upper lid retraction seen in some patients with Graves orbitopathy.[1] Since then, lateral lid flare (LLF) has been specifically addressed in most publications regarding procedures for the correction of upper lid retraction associated with Graves orbitopathy (GO).[2] Whether through an anterior or posterior approach, there is a constellation of techniques described to address upper eyelid retraction, including spacer grafts,[3] Müller's muscle excision,[4,5] aponeurotic recession,[6,7] or blepharotomy.[8,9] Most surgeons agree that lateral retraction requires special attention to be properly corrected.

Although modern techniques of lid contour quantification have confirmed the existence of the LLF,[10,11] the magnitude of lateral retraction is scarcely measured in the clinical setting. In fact, the methods designed so far to analyze the lid contour are based on specific custom made programs that are not available to clinicians. The decision of whether to perform more aggressive lateral surgery is thus entirely based on the surgeon's subjective appreciation of the presence or absence of the LLF. The present study is intended to investigate the potential role of lateral midpupil-eyelid distances in the detection and quantification of LLF.

Methods

In this study, a comparative cross-sectional analysis of the upper eyelid contour was performed for patients affected by GO and normal controls. Subjects in the GO group were selected from institutional photographic databases collected at two separate tertiary GO practices. All patients were euthyroid and were in the quiescent phase of GO. The control group consisted of age and sex matched volunteers. For both groups, primary position clinical photographs were selected for analysis. Subjects were excluded if they had undergone any prior eyelid or orbital surgery.

The images of both patients and controls were obtained parallel to the plane of the face, with the subject in primary

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position looking in to the camera. Digital images were analyzed using ImageJ software (National Institutes of Health, Bethesda, MD, USA). Horizontal head tilt was corrected digitally by aligning the inner canthi of both eyes to the horizontal plane. Pixel to millimeter conversion was performed utilizing a white-to-white corneal diameter of 11.7 mm.

Randomly selected right or left eye images were cropped to remove patient identifying features. All images were assessed by six experienced oculoplastic surgeons. Raters were tasked to provide a binary assessment as to the presence or absence of LLF. Only cases in which unanimous agreement was achieved were defined as LLF positive. The eyelids were classified into three subgroups: presence of LLF (G1), absence of LLF (G2) or non-unanimous LLF (G3).

As previously described,[12] Bézier lines were adjusted to the lid contour for both the GO and control group (CG). Lines were then sampled graphically with 1,000 points, yielding a resolution of 0.025 mm (Figure 1). Lateral midpupil lid margin distances (LMPD) were calculated as the vertical distance perpendicular to a horizontal line bisecting the pupil. Five measurements were performed at 10% intervals (mean = 1.25 mm) between the temporal limbus and lateral canthus (Figure 2). The 5 LMPD distances were calculated using python programming language software (Python Software Foundation, Beaverton, OR, USA). Each LMPD was divided by the MRD_1 in order to standardize for baseline MRD_1. The LMPD/MRD_1 (LMPDr) ratios express the curvature of the lateral contour as a percentage of the MRD_1.

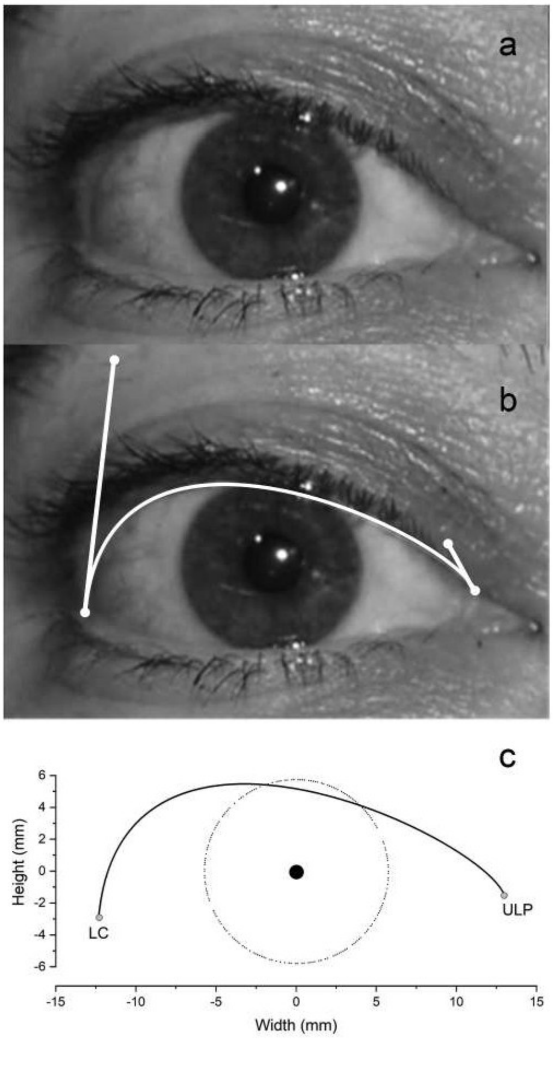

Figure 1. Eyelid contour measurement with Bézier lines.

Statistical analysis

Agreement among judges as to the presence of LLF was evaluated with the Fleiss' Kappa test.[13] Univariate logistic regression was performed to determine the contribution of each LMPDr to predicting the presence of LLF. The optimum cut-off value, sensitivity, specificity, and area under the ROC curve (AUC) were estimated for each lateral LMPD from receiver operating characteristic (ROC) curves. The lateral midpupil distance yielding the highest AUC was selected to analyze the contours of G3 group. The non-parametric Kruskal–Wallis one-way analysis of variance (ANOVA) with Dunn's post hoc test was used to compare the values of the contour parameters between groups.

Means and 95% CI interval were used to plot the lateral MRD ratios for both the control and GO groups.

Results

Overall 60 eyes in 60 patients, evenly split between the GO and control groups were assessed. Mid-pupil vertical marginal reflex distances (MRD_1) ranged from 3.2 mm to 9.0 mm (mean = 5.4 ± 1.7 SD).

The degree of agreement among surgeons regarding LLF in the GO group was relatively high (K = 0.69, z = 16.6, $p < .0001$). Twelve lids were unanimously classified as LLF positive (G1) and 7 unanimously classified as LLF negative (G2). There was no universal agreement regarding the presence or absence of LLF in 11 lids (G3).

Figure 3 shows the mean ±SE values for each of the five LMPD ratios in the CG, G1, G2 and G3 groups. In all 4 groups, LMPD ratios diminish from the center of the pupil towards the lateral canthus. Although this decay is significantly steeper for the CG than for the G1 group, there is considerable overlap among the GO groups overall G1 vs G2, $p = .09$, G2 vs G3, $p = .8$).

The ROC curve results for each LMPD ratio are described in Table 1. The LMPD values located at 1.25 and 2.5 mm medial to the lateral canthus (L5 and L4, respectively) yielded similar AUC values for GO and controls. At position 4 (2.5 mm medial to the lateral canthus) the sensitivity was greater.

Using the optimal cut-off point for the L_4MPD ratio (≥59.6%) as the criterion for the diagnosis of flare, 5 of the 11 previously undefined contours were labeled as LLF + and 6 as LLF -. Figure 4 shows the means and 95% CI of each LMPD ratio for the controls and patients now divided into LLF + (n = 18) and LLF – (n = 12) groups. As shown in Table 2 with the new criterion 3 LMPD ratios are significantly different between all groups.

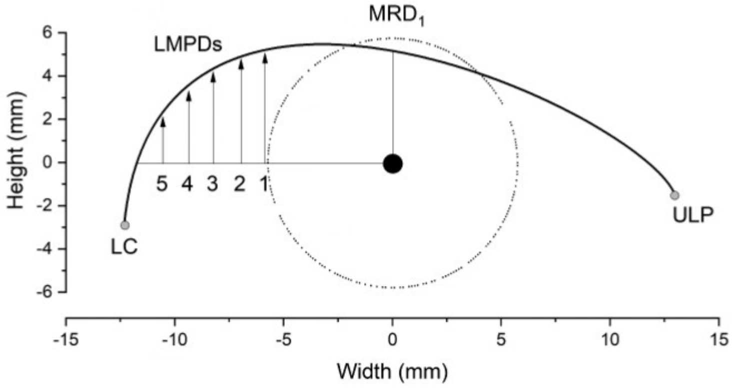

Figure 2. Location of LMPD on the temporal half of the lateral lid contour.

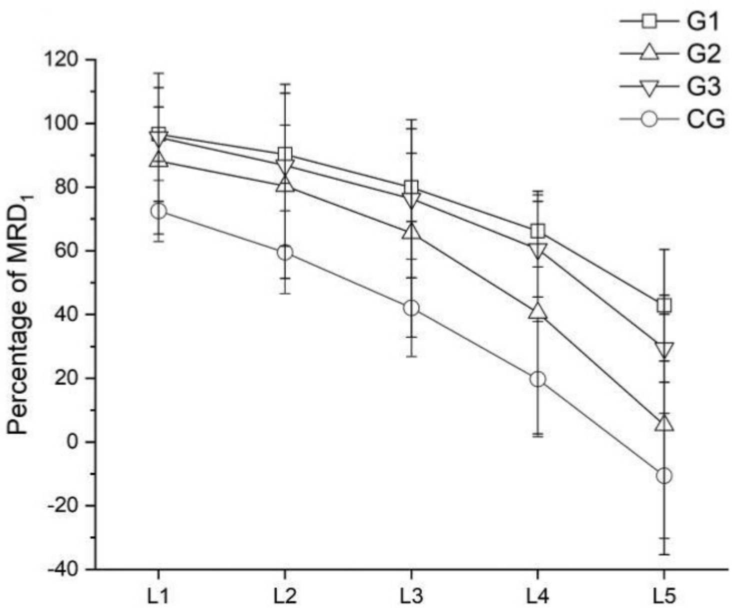

Figure 3. Subjective assessment of LLF. Mean lateral MRD ratios of controls and patients.

Table 1. Receiver operating characteristic curve analysis.

	Optimal Cut-off point	*Likelihood Ratio Test (p-value)*	Sensitivity	Specificity	AUC
L_5MPDr	≥ 34.7	0.0005	0.833	0.857	0.905
L_4MPDr	≥ 59.6	0.0005	0.917	0.857	0.905
L_3MPDr	≥76.7	0.0006	0.917	0.714	0.892
L_2MPDr	≥86.7	0.0021	0.917	0.714	0.857
L_1MPDr	≥90.6	0.0038	1.0	0.571	0.786

AUC (Area under the curve). (<, >) The direction of positive Flare

Discussion

The mechanism of LLF is a topic open to speculation. It has been related to the lateral extensions of Müller's muscle,[14] to the inflammatory process involving the lateral horn of the levator aponeurosis[15] or even to fibrosis of the intermuscular septum.[16] Despite the lack of agreement on the pathogenesis of LLF its importance for the surgical management of Graves upper eyelid retraction is a time-honored concept.[2] Quantitative measurement of enhanced lateral retraction is typically absent from publications regarding surgical management of Graves upper lid retraction. Typically, results are described as successful when the contour is assessed qualitatively as smooth or good.[7] More precise determination of lateral retraction would be useful to compare techniques and outcomes.

This is increasingly evident when considering the effect of orbital decompression on the lid contour is considered. According to conventional teaching, lid retraction surgery is performed after orbital decompression. This protocol,[17] which is based on the theory that orbital decompression leads to change in the lid contour, was further supported by Lemke who believed that, with variations in the position of the globe, the forces affect the upper eyelid shape.[18] However, experimental evidence supporting this theory is weak. To the best of our knowledge, there is just one article reporting a mean medial shift of the contour peak of 1.3 mm (p = .05) in 34 lids

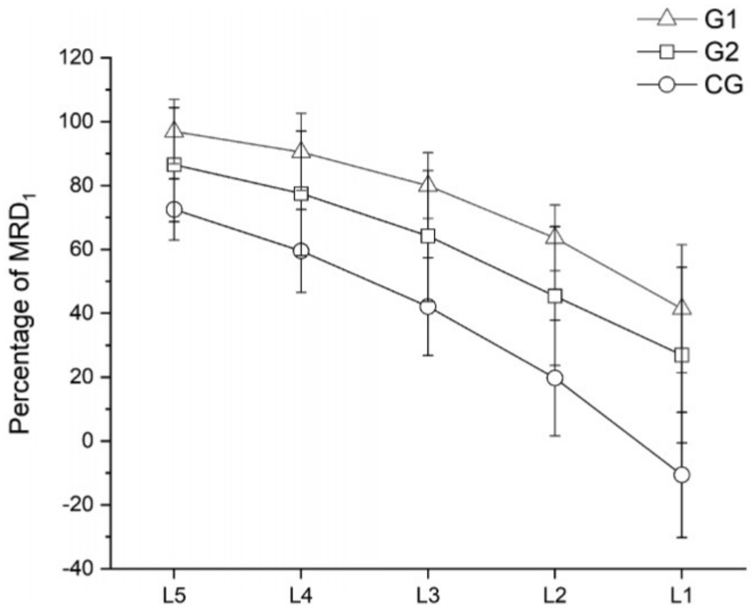

Figure 4. Lateral MPD ratios of the lids of controls and patients. LLF was classified as positive considering an L_4MPDr 60% or greater of the MRD_1.

Table 2. Mean ratios (Lateral LMPD/MRD_1) and median (IQR) at different positions between the temporal limbus and lateral canthus.

	Flare +		Flare -		Controls		
LMPD	Mean	Median (IQR)	Mean	Median (IQR)	Mean	Median (IQR)	p-value (*)
1	99.0	96.9 (10.1)[a]	85.7	86.5 (17.9)[a]	70.8	72.5 (9.6)[b]	<.0001
2	92.5	90.5 (12.1)[a]	75.0	77.5 (19.5)[b]	56.7	59.5 (13.0)[c]	<.0001
3	82.1	80.0 (10.3)[a]	60.8	64.2 (20.5)[b]	38.6	42.1 (15.3)[c]	<.0001
4	66.2	63.6 (10.3)[a]	41.8	45.4 (21.7)[b]	16.4	19.7 (18.1)[c]	<.0001
5	40.8	41.4 (20)[a]	16.3	26.9 (27.5)[a]	−10.6	−10.6 (19.6)[b]	<.0001

(*) Kruskal–Wallis test. The superscript letters indicate differences between the groups in the Dunn test post hoc.

after inferomedial orbital decompression.[19] Other studies seem to contradict the importance of the effect of orbital decompression on lid contour. In a large series of orbital decompressions, no difference was detected in the rate of LLF under correction when the lid surgery was performed simultaneously with, of successively after, orbital decompression.[4]

LLF is a specific deformation of the lateral portion of the lid and is usually assessed in the literature as a binary variable (present or absent). In clinical settings, this diagnosis is entirely based on a subjective understanding of the normal eyelid contour and a comparison between the medial and lateral curvature of the lid. The subjective comparison of the curvature of sectors of the lid contour is not easy. In our sample, the surgeons did not agree on the presence of the LLF in 37% of the lids. The value of the Cohen's k test was 0.67 which is considered to be substantial but not excellent.[20] Therefore, a simple method to measure the lateral lid curvature would be clinically useful. So far this objective has proven to be elusive. The main parameters used for this purpose are the location of the contour peak and the ratio between the lateral and medial area under the lid.[21,22] The location of the contour peak is defined as the first derivative of the contour equal to zero. It can be estimated as the point where a horizontal line forms a tangent to the upper eyelid margin.[21] The ratio between the lateral and medial area under the upper lid is another measurement that has been proposed to measure LLF.[22] These measurements require extensive image processing and calculation, making clinical utility limited. Additionally, both are subject to some criticism due to their dependency on medial eyelid curvature.

In the present investigation, receiver operating characteristic curves showed that a single measurement of lateral MRD located 10% to 30% medial to the lateral canthus allows a clear separation of contours with and without LLF. The concept of multiple MRDs was used for the first time to analyze the upper lid contour by Danesh et al. in 2018.[23] In the cited study, 4 medial and 5 lateral MRDs were measured at 2 mm intervals of pre- and post-operative ptosis cases. This approach does have some limit on inter-subject comparison due to variation in horizontal eyelid length in the population. As such a fixed distance may represent a different segment of the eyelid for alternate individuals.

We prefer to distribute the lateral MRDs at 10% intervals of the distance between the temporal corneal limbus and the lateral canthus. This method allows for the description of lateral lid elevation at the same position along the eyelid margin across multiple subjects. As pointed out by Danesh et al., this simple and intuitive method can be used to characterize changes in lid contour.[23] As the LLF represents a sectorial contour change, a single lateral MRD measurement is sufficient to express this contour anomaly. The data presented in this discussion suggest that the position 10% medial to the lateral canthus can reliably predict LLF when the ratio of LMDR to MRD1 in that position is greater than 60%. This measurement is both sensitive and specific for LLF and can be utilized to assess a broad section of eyelids that may vary in horizontal length, contour and disease severity.

The main limitation of the present study was the sample size. We are planning to increase the number of participants and also to test the clinical usefulness of LMPLD to measure the effect of different procedures on the LLF.

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ARTIGO 3

Cruz AAV, Equitério B, Diniz SB, Garcia DM, Rootman DB, Goldberg RA, Galindo-Ferreiro A, Marqués-Fernández V, Sales-Sanz M. **Upper eyelid contour changes after orbital decompression in Graves orbitopathy**. Ophthalmic Plast Reconstr Surg. 2022;38(3):289-293.

ORIGINAL INVESTIGATION

Upper Eyelid Contour Changes After Orbital Decompression in Graves Orbitopathy

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Purpose: To evaluate the effect of orbital decompression on the upper eyelid contour.

Methods: A paired cross-sectional analysis of the upper eyelid contour was performed for 103 eyes of 66 patients who underwent orbital decompression. A control group of 26 normal subjects was also included. The eyelid contour of all participants were measured with Bézier lines adjusted to the eyelid contour and 9 midpupil eyelid margin (MPD) distances from a horizontal line bisecting the pupil. One central, corresponding to the margin reflex distance (MRD 1), and 8 equally distributed medially and laterally at 20% of the interval between the lines. Patients were classified as with flare if the height of the most lateral MPD relative to the MRD 1 was above the upper limit of the controls.

Results: Preoperatively 63 of the 103 contours were classified as flare + (F+). After decompression MRD_1 showed a mean decrease of 0.4 mm and the location of the contour shifted 0.8 mm medially. These changes were not correlated with proptosis reduction. Orbital decompression decreased the lateral curvature of the contours especially for the F+ lids. In 40% of the F+ eyelids the flare sign disappeared after decompression.

Conclusions: Orbital decompression affects the lateral eyelid contour and diminishes the amount of lateral eyelid retraction surgery necessary to correct the flare sign. In 40% of the patients, the eyelid contour is normalized with proptosis reduction only.

(*Ophthalmic Plast Reconstr Surg* 2022;38:289–293)

Upper eyelid retraction and proptosis are the most common manifestations of Graves orbitopathy (GO).[1] Upper eyelid retraction is so prevalent that it is one of the major criteria for the diagnosis of the disease.[2] Patients with GO who need orbital decompression often display different degrees of upper eyelid retraction which, according to traditional teaching, should always be addressed after decompression.[3] The rationale of this protocol is based on the assumption that staged procedures in GO provide better results and minimize the number of surgeries.[3] The evidence of the effect of proptosis on upper eyelid retraction is weak. Two previous studies have shown that small changes in margin reflex distance 1 (MRD_1) after decompression do not correlate with the amount of proptosis reduction.[4,5] The effect of decompression on upper eyelid contour is still a matter of discussion. A single article suggests that lateral eyelid flare is normalized once proptosis is reduced.[6] In the present article, we have compared the pre- and postoperative upper eyelid contours of a large series of patients who underwent orbital decompression for GO.

MATERIALS AND METHODS

The research followed the Declaration of Helsinki as amended in 2013 and was approved by the Institutional Review Board of the Hospital das Clínicas of the School of Medicine of Ribeirão Preto, University of São Paulo.

A paired comparative cross-sectional analysis of the upper eyelid contour was performed for 103 eyes of 66 patients (57 females and 9 males, with a mean ± SD age of 48.3 ± 11.8 years) who underwent orbital decompression under general anesthesia at 2 international centers over a 3-year period. Patients who underwent eyelid retraction surgery at the time of orbital decompression were excluded. The authors also did not include any patient who had vertical or horizontal postoperative strabismus. A control group of 26 normal subjects (mean ± SD age of 36.7 ± 12.4 years) with no medical history of eyelid surgery, orbital surgery or eyelid deformity was also included. Orbital decompression was performed in the quiescent phase of the disease defined as no detectable changes during serial clinical examinations in the patient's visual acuity, proptosis, strabismus, or eyelid retraction for at least 6 months. Data collected included demographic variables, surgical description of the orbital decompression, Hertel exophthalmometry, and pre- and postoperative standard digital images of the eyes. The deep lateral wall was approached in 69% of orbits either as a single lateral wall (36%), medial and lateral decompression (15.5%), or a 3-wall decompression (17.5%). Other techniques included medial only (27%) and inferomedial (4%) decompression. In the 3 wall and inferomedial procedures, the anterior strut was preserved to avoid hypoglobus.

Patients and controls were photographed with a digital camera positioned in the frontal plane at pupil height and with the subject in primary position of gaze. The images were analyzed using ImageJ software (National Institutes of Health, Bethesda, MD). Horizontal head tilts were corrected by aligning the inner canthi of OU to the horizontal plane. Pixel-to-millimeter calibration was performed by assuming a white-to-white corneal diameter of 11.7 mm. After this first step,

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Bézier lines were adjusted to the eyelid contour for both pre and post-decompression images. Using python programming language (Python Software Foundation, Beaverton, OR), Bézier curves were sampled graphically with 1,000 points, yielding a spatial resolution of 0.025 mm.

Nine midpupil eyelid margin (MPD) distances were measured from a horizontal line bisecting the pupil: 1 central, corresponding to the MRD_1, and 8 equally distributed medially (MMPD) and laterally (LMPD) at 20% intervals between the pupil and the medial and lateral canthi, respectively. As show in Figure 1, the lateral MPDs were designated as L20, L40, L60, and L80 and the medial as M20, M40, M60, and M80. To eliminate the effect of MRD1 on the magnitude of the noncentral MPDs, each MPD was divided by the MRD1. This ratio expresses the curvature of the lateral contour as a percentage of the MRD1. The position of the contour peak (CP) relative to the center of the pupil was also calculated. Negative values indicate lateral displacement of the CP.

Preoperative eyelid contours of the patients were classified as with flare (F+) or without flare (F–), if the height of the most lateral MPD relative to the MRD_1 (L80/MRD_1 or L80r) was above the upper limit of controls. As it has been already shown this single measurement is highly sensitive and specific for the diagnosis of flare.[7]

Statistical Analysis. Results are expressed as means and 95% confidence intervals. Repeated measures analysis of variance with post hoc Tukey tests were used to compare changes of the MPD values induced by orbital decompression. Paired and unpaired-t tests were used to compare changes induced by orbital decompression. Pearson product-moment correlation coefficients (r) were calculated between changes of Hertel and MPDs and Hertel and position of the CP.

RESULTS

Following orbital decompression, the mean preoperative MRD_1 (5.4 mm) decreased to 5.0 mm ($P < 0.0001$). The CP was 2.2 mm lateral to the pupil center before decompression and moved 0.8 mm medially after surgery ($p < 0.0001$). The MRD_1 changes were not correlated with the degree of proptosis reduction. A weak correlation (r = 0.35, $p = 0.03$) was obtained between the proptosis reduction and the CP changes for the lids without flare. For the subgroup of lids with positive flare the correlation was not significant (r = 0.15, $p = 0.23$, Fig. 2)

Table 1 lists the values (mean, 95% CI, and range) of the MPDs relative to MRD_1 for the controls.

Considering a L80r greater than 46% of the MRD1 as a criterion for flare positivity, 63 of the 103 contours were classified as positive flare (F+) and 40 as negative flare (F–). The proptosis reduction did not differ between these 2 groups (3.9 ± 0.3 mm for the F+ group and 3.8 ± 0.3 mm for the F– group, $p = 0.73$). However, as shown in Figure 3, the effect of orbital decompression on the lateral segment of these 2 groups of contours was distinct.

The ANOVA showed orbital decompression decreased the lateral MPD ratios of both groups of lids. For the F– contours, there was a mean decrease of 6.6% (p = 0.0007) at L80 and 6% at L60 (p = 0.007). For the F+ contours, the decrease in MPD began at L40 (5%, $p = 0.0006$), increased to 9% at L60 and reached 13% at L80.

On the medial segment of the contours the ANOVA showed that only for the F+ group there was a small significant increase of 3.8% at M80.

We compared the lateral MPDs of the eyes that underwent isolated deep lateral decompression (n = 37) and those whose orbits were decompressed medially only (medial wall + inferomedial, n = 32). There was no difference between the groups with respect neither to the mean proptosis reduction (lateral = –3.4 mm, medial = –2.8 mm, $p = 0.12$) nor to the MRD1 (lateral = –0.26 mm, medial = –0.46 mm, $p = 0.34$). The 2-way ANOVA (decompression technique (medial vs lateral) and differences between pre and postlateral MPDs) showed in both groups the lateral MPDs changes diminished toward the lateral canthus. However, the lowering effect of decompression was 3.7% greater for orbits that underwent the lateral decompression (F = 4.63, $p = 0.035$).

Overall, the analysis of all contours F+ indicated that orbital decompression corrected the lateral flare in 40% of the eyelids, Figure 4.

DISCUSSION

There are 2 opposite views regarding the etiology of enhanced lateral upper eyelid retraction induced by GO. One advocates that proptosis may cause lateral eye exposure. The other mechanism is centered on the anatomic differences between the medial and lateral levator horns. According to this theory, the lateral eyelid flare is a sign of excessive levator tension.[8]

The possible effect of globe protrusion on the upper eyelid contour was proposed by Lemke in 1991.[9] In an elegant theoretical article, the author emphasized that because the orbital axis diverges from the visual axis in the primary position of gaze, the enhanced lateral exposure is a normal feature. Therefore, when the globe is proptotic, the tarsal-ligament band cannot compensate for the lateral exposure, and lateral flare ensues.[9] However, there is little data supporting this theory. Van den Bosch, in 1998, was probably the first to notice that transantral inferomedial orbital decompression had a deleterious effect on eyelid contour. In his experience,

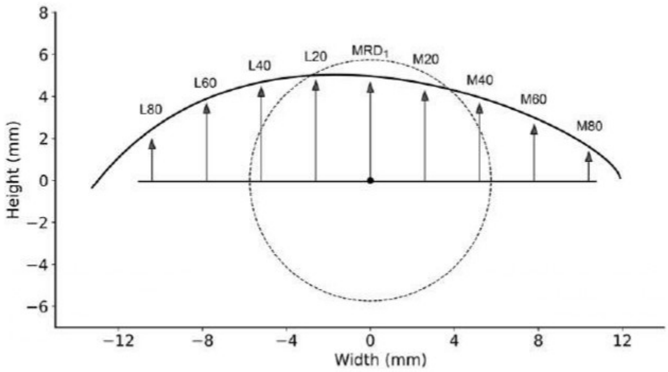

FIG. 1. Measurement of 9 midpupil-eyelid distances of the upper eyelid contour.

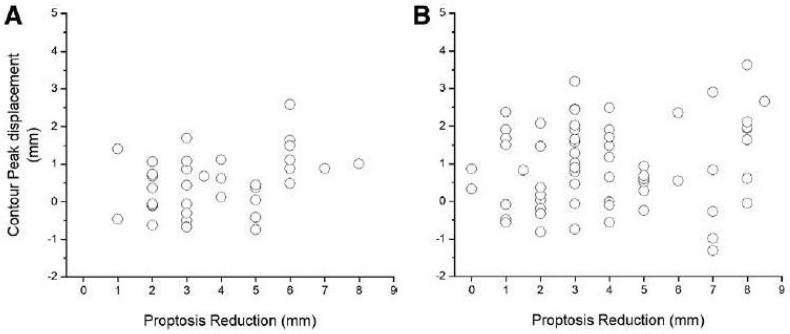

FIG. 2. Correlations between proptosis reduction and contour peak changes. **A,** Eyelids without flare (r = 0.35, $p = 0.03$). **B,** Flare positive eyelids (r = 0.15, $p = 0.23$).

several patients who developed hypoglobus after decompression developed a flat eyelid contour when the retraction was corrected.[10]

In the modern era of orbital decompression, Chang et al. studied the relationship between proptosis reduction and eyelid contour modification. The authors analyzed photographs of 38 eyes following inferomedial decompression, and based only on the postoperative nasal change of the CP, they concluded that orbital decompression may significantly improve the eyelid contours.[6] However, shifts in the CP position may not correct the lateral eyelid flare. Eyelid peaks are variable, poorly correlated with the amount of decompression, and might be influenced by a horizontal inward displacement of the globe, which is a known finding when the medial wall of the orbit is removed.[11]

The present study shows that, in patients with quiescent TED, decompression appears to have a net reductive effect on lateral eyelid retraction. Normal eyelid contours are mildly affected by proptosis reduction; whereas contours with flare have diminished lateral MPDs as a result of orbital decompression. Proptosis has a secondary role in the etiology of enhanced lateral eyelid retraction. After decompression, the mean reduction of the most lateral MPD was only 13%, and the lateral flare persisted in 60% of patients. The slight effect of orbital decompression on upper eyelid retraction was not correlated with the magnitude of proptosis reduction. This finding is in agreement with previous studies that also did not find any relation between the effect of decompression and an eventual reduction of eyelid retraction.[4,5]

If proptosis does not fully explain the eyelid contour abnormality in GO, increased tension on the levator muscle might be the key factor in the etiology of lateral flare. As shown in orbital imaging studies, inflammatory changes in the levator aponeurosis are associated with eyelid retraction.[12] As described by Whitnall[13] and corroborated by many anatomic studies,[14] the lateral horn of the aponeurosis is much thicker and stronger than the medial horn. In addition, the angle between the lateral horn and the levator muscle is narrower than the angle formed by the muscle and the medial horn. This spatial configuration contributes to a stronger lateral pull of the aponeurosis.[15]

Given the modest descent of the upper eyelid after orbital decompression, surgeons may consider concomitant correction of upper eyelid flare and proptosis. The rationale behind a simultaneous approach is that there may be a need for upper eyelid adjustment following retraction surgery after decompression. Lowering the upper eyelid during an orbital decompression also improves the cosmetic result of the procedure. Ben Simon et al. have shown that the staged approach is not superior to simultaneous decompression and eyelid correction.[16] Although the benefit of simultaneous correction of the proptosis and the eyelid retraction at this point is just a speculation we believe that satisfactory results of eyelid correction under general anesthesia during decompression surgery can be obtained if the magnitude of eyelid flare is carefully evaluated and if the surgeon has enough experience in dealing with these difficult cases. However, a detailed quantitative analysis of eyelid contour for cases of concomitant decompression and eyelid retraction repair, it is still missing in the literature.

TABLE 1. Means, 95% CI and Range of the MPD Ratio (%) Values of the Control Group

	Controls				
Position	**Mean**	**Lower 95% CI**	**Upper 95% CI**	**Min**	**Max**
L80	19.3	14.8	23.8	–13.1	46.5
L60	57.9	54.8	61.0	32.9	76.4
L40	82.5	80.6	84.5	67.3.	93.1
L20	96.1	95.1	97.0	89.4	102.0
M20	96.1	95.3	96.8	91.3	102.0
M40	85.1	83.4	86.7	74.1	96.0
M60	66.6	63.8	69.4	44.0	80.9
M80	38.8	34.3	43.2	–1.7	53.9

CI indicates confidence intervals; MPD, midpupil eyelid margin.

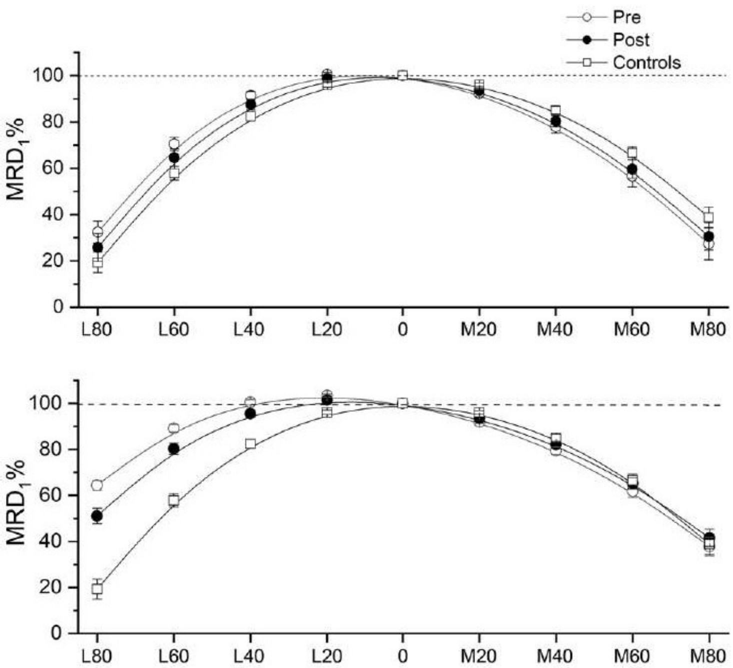

FIG. 3. Contour changes after orbital decompression. Top, flare negative; Bottom, flare positive.

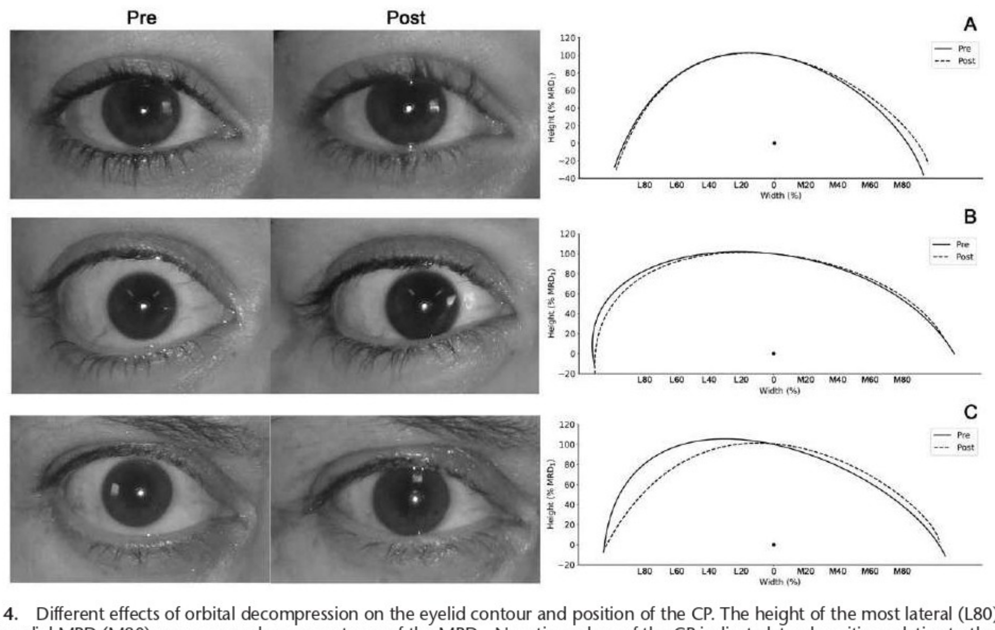

FIG. 4. Different effects of orbital decompression on the eyelid contour and position of the CP. The height of the most lateral (L80) and medial MPD (M80) are expressed as percentages of the MRD_1. Negative values of the CP indicate lateral position relative to the pupil center in millimeters. **A,** No effect on the flare on a normal contour. Preop: L80 = 40%, M80: Preop = 21%, CP = −1.5. Postop: L80 = 42%; M80 = 26%, CP = −1.9. **B,** Persistence of eyelid flare despite proptosis reduction. Preop: L80: = 73%, M80 = 42%, CP = −2.7. Postop = L80 = 71%; M80 = 51%, CP = −2.9. **C,** Normalized lateral contour after decompression. Preop: L80 = 74%, M80 = 21%; CP = −3.7; Postop = L80 = 46%; M80 = 26%; CP = −1.7. CP indicates contour peak; MPD, midpupil eyelid margin.

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ARTIGO 4

Equitério B, Garcia D, Galindo-Ferreiro A, Marqués-Fernández V, Sales-Sanz M, Cruz AAV. **Effect of rim-off deep lateral orbital decompression on interpalpebral fissure shape**. Ophthalmic Plast Reconstr Surg. 2023;39(2):170-173.

ORIGINAL INVESTIGATION

Effect of Rim-Off Deep Lateral Orbital Decompression on Interpalpebral Fissure Shape

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Purpose: The purpose of this study is to compare the palpebral fissure shape after rim-off deep lateral decompression with and without restoration of the lateral orbital rim.

Methods: Retrospective cross-sectional quantitative analysis of the palpebral fissure images of 17 patients (25 eyes) who underwent rim-off deep lateral orbital decompression without repositioning of the rim (G1) and of 20 patients (34 eyes) operated with rim restoration. Quantification of palpebral fissure images included MRD_1 and MRD_2, two lateral mid-pupil lid margin (MPD) distances, the width of the palpebral fissure, and the height and shape of the lateral canthus.

Results: Proptosis reduction did not differ significantly between G1 and G2. In both groups, decompression reduced the mean values of the MRD_1 and MRD_2, the lateral height of the upper eyelid, and the height and angle of the lateral canthus. The palpebral fissure width and lateral height of the lateral lower eyelid were not affected. There was no significant difference between the mean changes of G1 and G2. Multivariate analysis showed that the lateral canthus decrease was correlated with changes in MRD_1 and MRD_2.

Conclusions: Small changes in palpebral fissure shape after deep lateral decompression are not dependent on the presence or absence of the lateral rim.

(*Ophthalmic Plast Reconstr Surg* 2023;39:170–173)

INTRODUCTION

The removal of the orbital plate of the greater sphenoid wing is firmly established in the arsenal of orbital surgeons as an effective procedure for the reduction of proptosis in patients with Graves' orbitopathy.[1] This modality of orbital decompression can be performed from the orbital side (ab-interno), or from the temporal fossa (ab-externo). In the latter modality, to reach the sphenoid trigone the surgeon needs to thin out[2,3] or to remove (rim-off procedure) the lateral orbital rim, which is usually repositioned at the end of decompression.[4] However, some surgeons believe that the cosmetic and functional effects of the absence of the rim are not significant and do not restore the integrity of the lateral wall after decompression, leaving the lateral canthus without any bony attachment.[5,6]

The literature on the effects of the absence of the rim on palpebral fissure shape is extremely reduced. The authors are aware of just one article on the horizontal motion and cosmesis of the lateral canthus after complete removal of the rim.[7] The authors present here the results of deep lateral rim-off decompression with and without restoration of the rim on the shape of the palpebral fissure.

METHODS

The research followed the Declaration of Helsinki as amended in 2013 and was approved by the Institutional Review Board of the Hospital das Clínicas of the School of Medicine of Ribeirão Preto, University of São Paulo. Written informed consent was obtained from patients for the publication of identifiable clinical pictures.

This study is a cross-sectional comparison of the effects of deep lateral orbital decompression on lateral canthus height, palpebral fissure width, and lateral upper eyelid height. The authors measured the palpebral fissure of 59 eyes of 37 patients who underwent deep lateral orbital decompression for proptosis reduction at 2 international centers over a period of 3 years. All lateral orbital decompressions were performed in the quiescent phase of the disease, with the removal of the rim which was not repositioned in 25 orbits of 17 patients (group 1 or G1, 12 females) with ages ranging from 22 to 79 years (mean = 48.8 ± 15.7 SD) and repositioned in 34 orbits of 20 patients (group 2 or G2, 17 females), with ages ranging from 25 to 60 years (mean = 47.8 ± 9.2 SD). There was no difference between groups regarding the age and male: female proportion. The medial wall was also removed in 9 orbits of G1 and 14 of G2. Patients who underwent eyelid retraction surgery at the time or after the orbital decompression were excluded. Data collected included demographic variables, surgical description of the orbital decompression, and pre- and postoperative standard digital images of the eyes. Postoperative photos were taken at least 6 months after surgery. Proptosis reduction was measured in G1 with CT axial slices using the posterior clinoid as a fixed reference point and with conventional exophthalmometry in G2.

The patients were photographed with a digital camera positioned in the frontal plane at pupil height and with the subject in the primary position of gaze. The images were analyzed using ImageJ software (National Institutes of Health, Bethesda, MD, U.S.A.). Horizontal head tilts were corrected by aligning the inner canthi of OU to the horizontal plane. Pixel-to-millimeter calibration was performed by assuming a white-to-white corneal diameter of 11.7 mm. The upper lid contours for both pre- and postdecompression images were expressed with Bézier curved lines and sampled graphically with 1,000 points, yielding a spatial resolution of 0.025 mm.

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Ophthalmic Plast Reconstr Surg, Vol. 39, No. 2, 2023 *Rim-Off Deep Lateral Decompression*

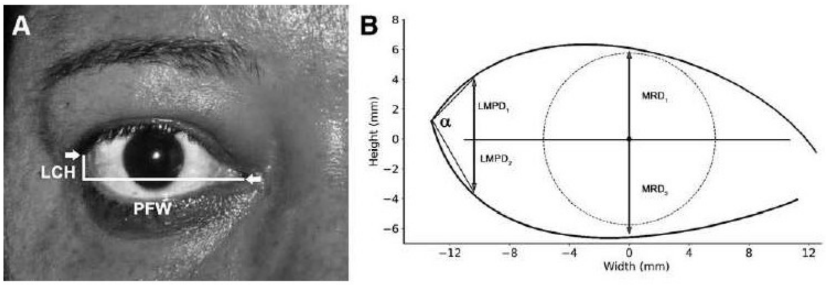

FIG. 1. Palpebral fissure measurements. **A,** LCH, lateral canthus height; PFW, palpebral fissure width. **B,** MRD1 – margin distance 1, Lateral Midpupil Distance$_1$ and LPMD$_2$ lateral contour height at 80% of the lateral segment of the upper lid. Lateral canthus angle (α).

Four mid-pupil lid margin distances (MPLD) were measured from a horizontal line bisecting the pupil: 2 of them central, corresponding to the MRD_1 and MRD_2 and 2 lateral, one superiorly (Lateral Midpupil Distance$_1$) and the other inferiorly (Lateral Midpupil Distance$_2$) at 80% of the interval between the pupil and the lateral canthus. These upper and lower Lateral Midpupil Distances were respectively divided by MRD_1 and MRD2 to be expressed as a percentage of the lid height. Other parameters analyzed included the width of the palpebral fissure and the height and shape of the lateral canthus defined as the angle formed by the upper and lower eyelids (Fig. 1).

SURGICAL TECHNIQUE

The surgical procedure has been well described in the literature, with small variations.[4–8] Briefly, the lateral orbital rim is exposed with a lid crease or lateral canthal incision and the temporalis muscle is detached from the outer border of the rim. The periosteum is then incised along the rim and dissected from the inner surface of the lateral wall. Holes were predrilled above and below the bony incisions. Using a reciprocating saw, 2 osteotomies are performed: a superior one at the level of the frontozygomatic suture and an inferior one just above the zygomatic arch. The rim is then removed with rongeurs, and the bony resection is augmented through the sphenoid marrow with cutting and diamond burrs until the dura-mater plane is reached. Bone removal is augmented from the lacrimal gland fossa to the inferior orbital fissure. The periorbita is opened to allow the fat to prolapse towards the temporal fossa and no fat removal was performed. The rim was repositioned in the correct position only in G2 patients. Bony closure was made with nonabsorbable sutures. As the temporalis muscle dissection was minimized the muscle was not secured to the rim. The authors just closed the orbicularis muscle and the skin with 6.0 absorbable and nonabsorbable sutures respectively.

STATISTICAL ANALYSIS

Paired *t*-tests were employed to analyze the effect of the decompression on parameters of the palpebral shape within each group. Intergroup differences induced by the procedures were compared by the *t*-test for independent samples. Multiple regression was employed to test the relationship between the effects of upper and lower eyelid positional changes on the lateral canthus angle.

RESULTS

The average proptosis reduction did not differ between groups (G1 = 4.1 [2.65] mm, G2 = 4.6 [2.23]; $p = 0.48$). As shown in Table 1, the effect of orbital decompression on the palpebral shape of both groups, albeit significant, was minute. In G1 the decompression significantly reduced the mean values of MRD_1, MRD_2, the lateral height of the upper eyelid, and the height and angle of the lateral canthus. The width of the palpebral fissure and the lateral height of the lower eyelid were not affected. The same pattern of change was observed in G2, except for the decrease in the height of the lateral canthus, which was not significant. All of these effects were not clinically significant and did not differ between groups (Fig. 2).

Figure 3 shows the relationship between the changes in MRD_1 and MRD_2 and in the lateral canthal angle. A multiple regression considering the changes in MRD_1 and MRD_2 in G1 and G2 as independent variables showed that the reduction of the lateral canthus angle was not related to the group ($p = 0.95$) and was significantly associated with the reduction of MRD_1, ($p = 0.007$) and MRD_2 ($p < 0.0001$).

DISCUSSION

References to the permanent removal of the lateral rim during orbital decompression can be traced to the early decades of the nineteenth century. According to Guyton,[9] who published a detailed description of the early lateral decompressions in 1946, Swift in 1935 operated on a patient with unilateral exophthalmos and did not replace the rim at the end of the procedure. In more recent years the rim is removed only when the procedure is performed from the temporalis fossa toward the orbit.[2] In this ab-externo technique, rim removal increases the visibility of the deep portion of the lateral wall, avoids pressure on the orbital contents, and reduces the need to retract the temporalis muscle.[4]

Permanent removal of the rim is not a popular choice among orbital surgeons. In a recent systematic review of deep lateral decompression,[1] the rim was left removed in only 8 articles by 5 different surgeons.[5,7,8,10–14] The authors believe that this paucity of data on the effects of rim removal on the interpalpebral fissure shape is related to the theoretical complications associated with the absence of the rim. Shore[15] advocated the use of a miniplate to reconstruct the lateral rim to prevent a series of possible problems, including the misalignment of the interpalpebral fissure, lower eyelid retraction, the development of entropion or ectropion, and lateral muscle imbalance. The reconstruction of the rim would also be important to establish a properly lateral canthal angle shape.[15] None of these side effects were observed in our patients with or without the rim. Our results show that deep lateral compression affects the interpalpebral fissure shape in the same way regardless of the presence or absence of the lateral orbital rim. The horizontal position of the lateral canthus does not change when the rim is not repositioned. The reduction of the lateral canthus angle depends on the diminution of the upper and lower eyelid retraction and not on the absence of the rim. In our patients, lid crease and lateral canthal incisions were adopted. These approaches are less invasive than the direct canthal incision and thus have less effect on the canthal shape. From a cosmetic perspective, the authors did not observe any deformation of the temporal fossa as reported when the external approach was performed using rim sparing techniques.[16,17]

TABLE. Mean and standard deviations of palpebral fissure measurements before and after deep lateral decompression

	Group 1			Group 2			Intergroup comparison of the pre- and postdifferences
Measurements	Preop	Postop	Difference	Preop	Postop	Difference	*p*
MRD_1 (mm)	5.3 (1.84)	4.5 (1.56)	0.9*	5.3 (1.50)	4.7(1.39)	0.6*	0.33
MRD_2 (mm)	7.5 (1.6)	7.0 (1.75)	0.5*	6.5 (1.19)	5.6 (1.11)	0.9*	0.15
Upper Lateral Midpupil Distance/MRD_1 (%)	47.5 (23.2)	25.7 (25.95)	21.9*	54.0 (22.1)	35.7 (20.4)	18*	0.45
Lower Lateral Midpupil Distance/MRD_2 (%)	70.4 (9.9)	69.9 (14.8)	0.5†	66.8 (9.1)	66.5 (11.3)	0.2†	0.94
Lateral canthal angle (degrees)	106.6 (13.2)	93.2 (18.4)	13.4*	102.9 (15.1)	88.0 (14.1)	14.9*	0.73
LCH (mm)	1.2 (2.14)	0.5 (2.32)	0.70*	2.2 (1.87)	1.9 (1.72)	0.3†	0.32
PFW (mm)	30.3 (1.77)	30.2 (2.94)	0.1†	31.0 (1.35)	30.3 (1.38)	0.8*	0.18

Pre- and postdifferences within each group:
* Significant,
† Not significant.
LCH, lateral canthus height; PFW, PFW, palpebral fissure width.

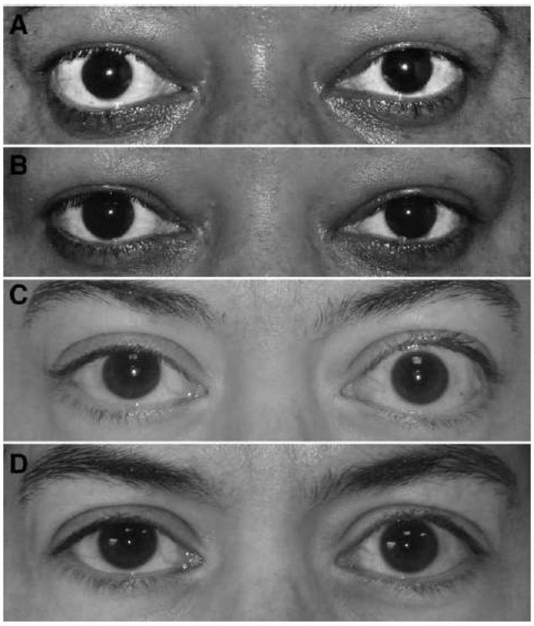

FIG. 2. Preoperative (**A, C**) and postoperative (**B, D**) clinical photographs of the palpebral fissure of 2 patients who underwent deep lateral rim-off orbital decompression without (top, OD) and with (bottom, OS) rim restoration.

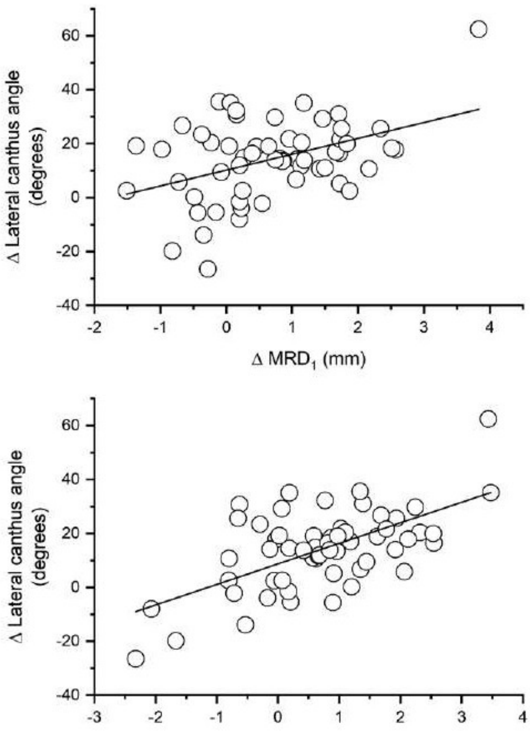

FIG. 3. Relationship between the changes (Δ) of MRD_1 (top), MRD_2 (bottom) and of lateral canthus angle: MRD_1 Pearson's r = 0.42, $p = 0.0012$; MRD_2 r = 0.61, $p < 0.0001$).

If the absence of the lateral rim does not have any detrimental consequences for the palpebral fissure, it does have some drawbacks. As reported in a few studies,[6,14] letting off the rim does not increase the degree of proptosis reduction by the decompression. If a canthal surgery is eventually needed, the absence of a rim might be a nuisance for canthal fixation. Lateral protection is another topic that may be considered, even though no data show an increase in orbital morbidity after rim-off decompression.

In conclusion, the catastrophic predictions for the palpebral fissure when the lateral rim is removed are not justified, but there are no surgical advantages of not repositioning the rim in the ab-externo deep lateral decompression.

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4. Discussão

As anomalias de contorno palpebral em pacientes com OG são uma constante nos ambulatórios de oculoplástica. A morfologia palpebral nesses pacientes é complexa, mas sua compreensão é fundamental para melhor correção cirúrgica. Normalmente, os resultados cirúrgicos são descritos como bem-sucedidos quando o contorno é avaliado qualitativamente como suave. Uma determinação mais precisa da retração lateral seria útil para comparar técnicas e resultados.

No primeiro trabalho publicado intitulado *Lid Flare Measurement with Lateral Midpupil Distances*, discutiu-se a determinação objetiva do FL nas pálpebras de pacientes com OG. O FL é uma deformação específica da porção lateral da pálpebra e, geralmente, é avaliada na literatura como uma variável binária (presente ou ausente). Essa avaliação costuma ser inteiramente subjetiva no ambiente clínico.

Neste estudo, o aumento lateral da pálpebra foi determinado quando havia unanimidade entre seis experientes cirurgiões oculoplásticos na classificação de fotografias obtidas de pacientes com OG. Na presente amostra, os cirurgiões não concordaram quanto à presença do *flare* lateral (FL) em 37% das pálpebras.

O grau de concordância entre os juízes, avaliado pelo teste Kappa de Fleiss, foi relativamente alto ($K = 0,69$, $z = 16,6$, $p<0,0001$). Os avaliadores classificaram 12 pálpebras com FL e sete sem FL em pacientes com OG. Não houve concordância sobre a presença ou ausência de FL em 11 pálpebras. Esses dados evidenciam a subjetividade na determinação do *flare,* como dito anteriormente.

O primeiro desafio deste estudo foi como determinar objetivamente o contorno da pálpebra superior de maneira a possibilitar a comparação da morfologia de múltiplas pálpebras. Foi encontrado um artigo de Danesh *et al*. (2018), que utilizaram, pela primeira vez, o método de múltiplas MRDs. No presente estudo foi utilizado o *software image J* para determinar o contorno palpebral com o *plugin bezier*. Na sequência, segmentou-se a pálpebra com as MRD laterais, que iam da linha horizontal, que passa pelo centro da pupila, à margem palpebral superior. Assim, foi possível realizar comparação objetiva entre as pálpebras.

Em todos os olhos, as MRDs diminuíram em direção ao canto lateral. Optou-se por distribuir as MRDs laterais em intervalos de 10% da distância entre a limbo corneano temporal e o canto lateral. Esse método permite a descrição da elevação lateral da pálpebra na mesma posição ao longo da margem da pálpebra.

A análise da curva ROC para essas distâncias, revelou que a quarta distância, a partir do centro, demonstrou alta sensibilidade e especificidade na detecção do aumento lateral da pálpebra. Nessa localização (2,5 mm medial ao canto lateral), a vertical com valor maior ou igual a 60% da MRD1 da pálpebra considerada indicou a presença de FL.

Este estudo evidenciou que uma única medição da distância lateral da linha que passa pela pupila até a margem da pálpebra, 2,5 mm medial ao canto lateral, é uma medida sensível e específica para o diagnóstico do *flare.*

No segundo estudo publicado, *Upper eyelid contour changes after orbital decompression in graves orbitopathy*, foram analisados os efeitos da descompressão orbitária no contorno palpebral superior. O estudo aponta que alguns são os mecanismos fisiopatológicos apontados como causadores do *flare*, mas existem duas teorias opostas sobre a etiologia do aumento da retração lateral da pálpebra superior induzida pela OG. Uma delas defende que a proptose pode causar exposição lateral do olho. O outro mecanismo está centrado nas diferenças anatômicas entre os cornos do elevador medial e lateral. O possível efeito da proptose no contorno da pálpebra superior foi proposto por Lemke (1991). Em seu estudo, o autor enfatizou que, devido à divergência entre o eixo orbital e o eixo visual na posição primária do olhar, a exposição lateral aumentada é uma característica normal. Portanto, quando o globo ocular está protuso, a faixa tarsoligamentar não pode compensar a exposição lateral, resultando em aumento da retração lateral. No entanto, há poucos dados que sustentam essa teoria. Nesse artigo, observou-se que, em pacientes com OG inativa, a descompressão parece ter efeito redutor no aumento da retração lateral da pálpebra. Os contornos normais da pálpebra são levemente afetados pela redução da proptose, enquanto os contornos anormais (flare +) apresentam diminuição da retração lateral como resultado da descompressão orbitária.

A proptose exerce papel secundário na etiologia do aumento da retração lateral da pálpebra. Após a descompressão, a redução média da MRD mais lateral foi de apenas 13%, e o FL persistiu em 60% dos pacientes. O leve efeito da descompressão orbitária na retração da pálpebra superior não foi correlacionado com a magnitude da redução da proptose. Se a proptose não explica completamente a anormalidade do contorno da pálpebra na OG, o aumento da tensão no músculo levantador pode ser o fator chave na etiologia do aumento do contorno lateral. Como mostrado em estudos de imagem, alterações inflamatórias na aponeurose do levantador estão associadas à retração da pálpebra. Conforme citado no artigo 3, o corno lateral da aponeurose é muito mais espesso e mais resistente do que o corno medial. Além disso, o ângulo entre o corno lateral e o músculo levantador é mais estreito do que o ângulo formado pelo músculo e o corno medial. Essa configuração espacial contribui para uma tração lateral mais forte da aponeurose.

Diante da leve descida da pálpebra superior após a descompressão orbitária, os cirurgiões podem considerar a correção concomitante da retração palpebral e da proptose. Acredita-se que resultados satisfatórios de correção da pálpebra, sob anestesia geral durante a cirurgia de descompressão, podem ser obtidos se a magnitude do aumento do contorno da pálpebra for cuidadosamente avaliada e se o cirurgião tiver experiência suficiente no tratamento desses casos difíceis. É aconselhável leve subcorreção para levar em conta a redução do aumento do contorno lateral com a diminuição da proptose.

Existe uma discussão com relação à manutenção ou não do rebordo orbitário em cirurgias de descompressão lateral profunda. A remoção permanente do rebordo não é uma escolha popular entre os cirurgiões que realizam descompressão orbitária. Foi realizada revisão sistemática de descompressão lateral profunda intitulada *Deep lateral orbital decompression for Graves orbitopathy: a systematic review,* e o rebordo foi removido em apenas oito estudos, por cinco cirurgiões diferentes. Assim, foi possível concluir que os autores acreditam que essa escassez de dados sobre os efeitos da remoção da margem na morfologia da fissura interpalpebral está relacionada às complicações teóricas associadas à ausência da margem que incluem desalinhamento da fissura interpalpebral, retração da pálpebra inferior, desenvolvimento de entrópio ou ectrópio e desequilíbrio muscular lateral. Em teoria, a reconstrução da margem também seria importante para estabelecer corretamente a forma do ângulo do canto lateral.

Referências à remoção permanente do rebordo orbitário durante a descompressão orbitária remontam às primeiras décadas do século XIX. De acordo com Guyton (1946), que publicou uma descrição detalhada das primeiras descompressões laterais, Swift (1935) operou um paciente com exoftalmia unilateral e não recolocou a margem no final do procedimento. Atualmente, a remoção da margem é feita apenas quando o procedimento é realizado da fossa temporal em direção à órbita. Nessa técnica ab-externo, a remoção da margem aumenta a visibilidade da porção profunda da parede lateral, evita pressão sobre o conteúdo orbital e reduz a necessidade de retrair o músculo temporal.

Foi publicado um artigo intitulado *Effect of Rim-Off deep lateral orbital decompression on interpalpebral fissure shape* com o objetivo de comparar os efeitos na morfologia da fenda palpebral entre pacientes que tiveram o rebordo orbitário retirado e aqueles que tiveram o rebordo mantido. Nenhum dos efeitos colaterais, citados anteriormente, foi observado nesses pacientes, com ou sem rebordo. Os resultados do presente estudo revelam que a descompressão lateral profunda afeta a forma da fissura interpalpebral da mesma maneira, independentemente da presença ou ausência do rebordo. A posição horizontal do canto lateral não muda quando a margem não é reposicionada. A redução do ângulo do canto lateral depende da diminuição da retração das pálpebras superior e inferior e não da ausência da margem. Para a presente amostra, foram adotadas incisões palpebrais e incisões cantais laterais. Essas abordagens são menos invasivas do que a incisão cantal direta e, portanto, têm menos efeito na forma do canto. Do ponto de vista cosmético, não se observou nenhuma deformação da fossa temporal.

Entretanto, é importante ressaltar que apesar da ausência do rebordo orbitário não apresentar consequências prejudiciais para a morfologia da fenda, a ausência do rebordo pode causar incômodo quando uma cirurgia cantal for necessária, como um *tarsal strip*, pois haveria dificuldade de fixação dos elementos na parede, agora ausente. Outro fato a ser considerado seria a proteção lateral, embora não haja dados que mostrem aumento na morbidade orbital após a descompressão sem a margem.

5. Conclusões

Com este estudo, concluiu-se que as previsões catastróficas para a fissura palpebral, quando o rebordo orbitário é removido, não são justificadas, mas não há vantagens cirúrgicas em não reposicionar a margem na descompressão lateral profunda ab-externo.

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7. Anexo

COMPROVANTE DE APROVAÇÃO DO COMITÊ DE ÉTICA

USP - HOSPITAL DAS CLÍNICAS DA FACULDADE DE MEDICINA DE RIBEIRÃO PRETO DA USP -

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Análise da morfologia da fenda palpebral em pacientes com orbitopatia de graves

Pesquisador: Bruna Sâmara Nogueira Equitério
Área Temática:
Versão: 1
CAAE: 44332121.6.0000.5440
Instituição Proponente: UNIVERSIDADE DE SAO PAULO
Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 4.604.345

Apresentação do Projeto:
A orbitopatia de graves é uma doença relacionada a distúrbios da tireóide prevalente nos ambulatórios de oculoplástica. Alguns casos podem ter como consequência ceratopatia de exposição, diplopia, retração palpebral, proptose neuropatia de nervo óptico necessitando em alguns casos de intervenção cirúrgica, denominada: descompressão orbitária. A retração palpebral é a principal característica dessa doença, e este estudo se propoe a quantificar de forma objetiva as mudanças morfológicas na fenda palpebral

Objetivo da Pesquisa:
Quantificar por meio de medidas verticais (horizontal que passa pela pupila até a borda palpebral superior) as mudanças na morfologia palpebral em pacientes com diagnóstico de orbitopatia de graves

Avaliação dos Riscos e Benefícios:
Pesquisa que apresenta risco mínimo.
Benefícios: mostrar de maneira objetiva como a cirurgia de descompressão orbitária interfere na morfologia palpebral e indicar ou contraindicar cirurgia para correção de retração palpebral de acordo com os resultados

Comentários e Considerações sobre a Pesquisa:
Trata-se de estudo observacional, haverá análise de imagens com o objetivo de comparar a

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Continuação do Parecer: 4.604.345

morfologia da fenda palpebral em pacientes com orbitopatia de graves submetidos ou não á descompressão de órbita

Considerações sobre os Termos de apresentação obrigatória:

Documentos devidamente apresentados. Solicita a dispensa de aplicação do Termo de Consentimento Livre e Esclarecido. O projeto de pesquisa fará uso de imagens contidas no banco de dados do laboratório de oculoplástica contendo apenas os olhos dos pacientes sendo impossível a identificação do paciente por meio das mesmas.

Recomendações:

não se aplica

Conclusões ou Pendências e Lista de Inadequações:

Diante do exposto e à luz da Resolução CNS 466/2012, o projeto de pesquisa, assim como a solicitação de dispensa de aplicação do Termo de Consentimento Livre e Esclarecido, podem ser enquadrados na categoria APROVADO.

Considerações Finais a critério do CEP:

Projeto Aprovado: Tendo em vista a legislação vigente, devem ser encaminhados ao CEP, relatórios parciais anuais referentes ao andamento da pesquisa e relatório final ao término do trabalho. Qualquer modificação do projeto original deve ser apresentada a este CEP em nova versão, de forma objetiva e com justificativas, para nova apreciação.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1693396.pdf	09/03/2021 18:01:39		Aceito
Outros	UPCCORRETA.pdf	09/03/2021 17:59:06	Bruna Sâmara Nogueira Equitério	Aceito
Folha de Rosto	FOLHAROSTROBRUNA.pdf	05/03/2021 16:10:22	Bruna Sâmara Nogueira Equitério	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	JustificativadedispensadoTCLE.pdf	28/02/2021 08:12:26	Bruna Sâmara Nogueira Equitério	Aceito
Cronograma	cronograma.pdf	28/02/2021 08:04:35	Bruna Sâmara Nogueira Equitério	Aceito
Orçamento	OrcamentoUPCPDF.pdf	28/02/2021 07:50:26	Bruna Sâmara Nogueira Equitério	Aceito

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Continuação do Parecer: 4.604.345

Projeto Detalhado / Brochura Investigador	projetopdf.pdf	28/02/2021 07:43:04	Bruna Sâmara Nogueira Equitério	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

RIBEIRAO PRETO, 22 de Março de 2021

Assinado por:
Marcelo Riberto
(Coordenador(a))

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