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Comparison of Surgical Decompression and Steroid Therapy for the Management of Traumatic Optic Neuropathy: A Systematic Review and Meta-Analysis

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Abstract

Study Design: A systematic review and meta-analysis.
Objective: Treatment of traumatic optic neuropathy (TON) has been a subject of debate for many decades due to the scarcity of evidence-based treatment protocols. This review compares surgical decompression (SD) and steroid therapy (ST) as treatment approaches in TON patients.
Methods: A PRISMA-guided systematic review using PubMed, Embase, Ovid and Scopus databases was performed till the last search date of July 31st 2021. The outcome of interest was an improvement in visual acuity. A meta-analysis of the odds ratio was performed using a random-effect model and sub-group analysis based upon criteria for assessment of improvement in visual acuity.
Results: Sixteen studies (including 1046 patients) were included in the review. The review could identify 590 patients treated with SD and 456 treated with ST. In addition, there was a second cohort of patients presenting with NLP (no light perception). A meta-analysis with a sub-group analysis revealed that there was statistically no significant difference between the two treatment approaches in terms of improvement in VA.
Conclusions: There is no difference in treatment results of SD or ST for TON. Several treatment protocols and different criteria for assessing visual acuity led to difficulty in generating evidence for selecting the correct treatment approach.

Keywords
traumatic optic neuropathy, surgical decompression, blindness , optic nerve injury , anterior cranial fossa

Introduction

Traumatic optic neuropathy (TON) has been historically documented as early as 500 BC by Hippocrates, who defined TON as the decreased vision from injury to the forehead region.[1] Later in 1845, Anton Nuhn described it as a lesion of the optic nerve resulting in post-traumatic amaurosis.[2] Another definition is impact injury to the optic nerve that results in complete or partial loss of function.[3] The incidence of vision loss after facial trauma is 2–5%.[2] Incidence of TON in head injury patients is less than 5%[4] or up to 6%, as reported in the case series of ZMC complex fractures.[5] The rare incidence of optic nerve injury makes it difficult to plan any randomised controlled trial (RCT) for its management. The treatment options of TON remain controversial and have evolved continuously with technology. However, the generally available steroids used in

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treatment have remained the same. The developing treatment protocols need regular updates regarding the recently reported results and outcome improvements. There is also a need to understand selection bias in treatment methods.

The clinical approach regarding the following is controversial with insufficient evidence.

(1) Type and indication of intervention.
(2) Timing of intervention. Assessment of post-treatment status.
(3) RCT trials available and their strength.

This review addresses the following research question – 'which treatment approach is best for traumatic optic neuropathy: Surgical decompression or steroid therapy'.

Materials and Methods

The systematic review followed the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P) 2015 statement.[6] The search protocol was registered in Prospero (registration number: CRD42020202839).

Literature Search Strategy

A comprehensive search of PubMed, Embase, Ovid and Scopus databases was conducted without any time restriction till last search date – July 31st 2021. The search strategy is mentioned in Table 1.

Keywords used for the search were as follows: 1. optic nerve injuries, 2. optic, 3. nerve, 4. injuries, 5. traumatic, 6. optic, 7. neuropathy and 8. traumatic optic neuropathy.

MeSH terms (PubMed) and Explosion (Embase) were used as tools to expand available articles for inclusion with the restriction of articles in the English language and humans as subjects of study.

Study Eligibility

Inclusion criteria. Following PICOS criteria were followed for inclusion criteria. Population(P): Patients with traumatic optic neuropathy due to craniomaxillofacial injuries. Participants/population: All patients with post-traumatic optic neuropathy associated with craniomaxillofacial injuries.

Intervention(I): All cases of post-traumatic optic neuropathy are managed surgically for optic nerve decompression.

Comparator(s)/control: All cases of post-traumatic optic neuropathy are managed non-surgically using steroid therapy.

Primary outcome (O): Improvement in visual acuity.

Studies included (S): Randomised control/clinical trials, controlled clinical trials, prospective cohort studies and case-controlled studies comparing surgical decompression to steroid therapy. Only English language papers were included in the review.

Exclusion criteria. Following exclusion criteria were used: 1. Review articles, 2. meta-analyses, 3. letters, 4. case reports, 5. opinion pieces, 6. case series of fewer than 10 cases and 7. studies comparing surgical decompression to only bed rest, head elevation and close observation without steroid therapy.

Data Extraction Process

The articles identified by search strategy were screened using the exclusion and inclusion criteria. These articles were used for data collection. The data were entered in a pre-piloted Excel sheet. All the papers included were reviewed by the first two authors (SP and GR); any disagreements were solved by the third author (AC). Fourth (AD) and fifth authors (BR) were involved in proofreading. Following data were extracted from the included studies: year, authors, country of origin, journal name, number of patients included, number of patients treated and improved with surgical optic nerve decompression and number of patients treated and improved with steroid therapy, the regimen of steroid therapy used and criteria used for assessment of improvement in visual acuity (VA).

Critical Appraisal of Included Studies

All non-randomised studies were assessed using the MINORS score,[7] where a maximum of 16 points were awarded

Table 1. Search Strategy Used in a Systematic Review.

Database	Search strategy	Number of results
PubMed	((('Optic nerve injuries' [MeSH Terms] OR (('optic' [All Fields] AND 'nerve' [All Fields]) AND 'injuries' [All Fields])) OR 'optic nerve injuries' [All Fields])	3674
Embase	'traumatic optic neuropathy' [All Fields]	1441
Scopus	TITLE-ABS-KEY-AUTH (traumatic AND optic AND neuropathy)	907
Ovid	traumatic optic neuropathy.mp. [mp = ti, ab, tx, ct]	1080

for non-comparative studies, and 24 points were awarded for comparative studies and RCT if any were assessed by the Jadad scale.[8]

Summary Measures and Synthesis of Results

The data were extracted, and the continuous variables were expressed as mean +/− standard deviation and the dichotomous variables were recorded as events of improvement in visual acuity. The extracted data were then subjected to meta-analysis. RevMan software 5 was used for the analysis. The heterogeneity of the studies was assessed with the Cochrane q and I^2 values. If the I^2 values were more than 50%, it suggested heterogeneity in the studies and a random-effects model was planned. If the I^2 were less than 50%, then the fixed-effects model was planned. The bias among the studies was assessed using the funnel plot. If heterogeneity were found to be more than 50%, a sub-group analysis would be performed to assess the reasons.

The number of patients treated and improved by surgical decompression and steroid therapy was recorded. A meta-analysis (odds ratio) was conducted with the I^2 test for heterogeneity to compare the two treatment protocols. Egger's funnel plot was drawn to test publication bias. Any improvement in the vision status was taken as a positive response.

Results

Result of Search Strategy (Study Selection)

A total of 7102 abstracts were identified in the PubMed Embase, Ovid and Scopus databases (Table 1). After screening for duplicate articles, 4967 abstracts were shortlisted. Abstracts were screened based on inclusion criteria, and 4819 abstracts were excluded and remaining 148 articles were selected for full-text reading. Screening of full-text articles revealed 19 papers that were suitable for data extraction. During data extraction, three articles were excluded for ambiguity in data. A total of 16 articles were included (Table 2) in the master chart for data extraction (Figure 1 depicts the PRISMA flow chart).

Description of studies. Included studies consisted of 11 retrospective studies. 1 RCT[16] and 5 non-randomised prospective studies (Table 2). Six out of eighteen studies provided details of treatment effects on patients with NLP (Table 3). In addition, nine studies described criteria for patient selection.

Critical appraisal of included studies. MINORS score was used for 15 studies. Maximum MINORS score was 16 for 5 studies and 24 for rest of the 10 studies. Jadad score was used only for the RCT by Chen et al[16] included in the meta-analysis. The respective critical appraisal scores are presented in Table 2.

Improvement in Visual Acuity

The articles were assessed for the total number of cases treated by steroid therapy (ST) and the total number of cases treated by surgical decompression (SD). The authors noted different treatment protocols and scales for testing visual acuity. There were different criteria used for the assessment of improvement in visual acuity.

Synthesis of continuous data was not feasible, and dichotomous data were synthesized based upon the events of improvement in visual acuity as defined by different criteria used by authors.

A total of 1046 patients from 16 studies were included in the meta-analysis, of which 590 patients underwent surgical decompression with 343 events of improvement in visual acuity. Four hundred fifty-six patients underwent medical management with two hundred fifty-two events of improvement in visual acuity (Table 2).

Ten authors used Snellen chart (SC)–based criteria, three authors used Log MAR values (minimum angle of resolution) based on Snellen chart, one author used Landolt's ring, one author used VEP and one author used percentage Log MAR values (Table 2).

The studies reported improvement in visual acuity based on different criteria. Hence, there was heterogeneity in the data, which mandated sub-group analysis based upon the criteria used.

Meta-analysis (odd ratio) was conducted, and a significant heterogeneity mandated a sub-group analysis based upon different criteria (mentioned below) used for reporting improvement in visual

(i) One line improvement in SC.
(ii) Two-line improvement in SC.
(iii) Three-line improvement in SC.
(iv) Log MAR values from SC.
(v) Landolt's ring assessment (LR).
(vi) Percentage improvement in Log MAR values.

There was significant heterogeneity I^2 = 66% among the studies which mandated a random-effect model. Meta-analysis of extracted data showed no significant difference in the overall visual improvement by SD or ST. A sub-group analysis of different criteria for visual improvement showed no statistically significant difference between the sub-groups with overall heterogeneity I^2 = 37.3% (Figure 2). However, the sub-group using one-line improvement in SC as criteria for improvement showed treatment results in favour of ST (test for overall effect Z = 2.38, P = .02).

Table 2. Characteristics of Studies Included in the Systematic Review.

	Year	Author	Study design	Treated SD	Imp-SD	Treated-ST	Imp-ST	Tech for SD	VA	ST used	MS	JS
1	1989	Simmon et al.[9]	RS	4	3	4	1	TE	SC	ND	9/16	NA
2	1992	*Mauriello et al.[10]	RS	7	4	16	9	TCon	SC	ND	11/16	NA
3	1993	Mahapatra et al.[4]	NRPS	45	17	50	25	TE/TC	VEP	DMS	13/16	NA
4	1996	*P.I. Chou et al.[1]	RS	25	15	23	13	TE/TC	SC	PRS	21/24	NA
5	1999	*Levine et al.[11]	NRPS	33	25	85	64	MP	Log MAR SC	ND	19/24	NA
6	1999	*S.Mine et al.[12]	RS	12	9	24	14	TC	LR	DMS	19/24	NA
7	2000	Kountakis et al.[13]	RS	17	14	34	11	TS	SC	MPRS	21/24	NA
8	2003	Rajiniganth et al.[14]	NRPC	30	15	18	10	TS	SC	MPRS	22/24	NA
9	2004	Yang et al.[15]	RS	24	10	18	8	TC	Log MAR SC	MPRS	12/24	NA
10	2004	Goldenberg et al.[16]	*RS*	*4*	*3*	*11*	*4*	*NM*	*ND*	*PRS*	*19/24*	NA
11	2006	*Shibuya et al.[2]	RS	10	3	28	18	NM	Log MAR SC	MPRS	13/16	NA
12	2008	H Li et al.[17]	NRPS	176	96	61	31	TS	SC	DMS	17/24	NA
13	2014	William et al.[18]	RS	91	75	24	10	NM	SC	MPRS	18/24	NA
14	2018	Min Chen et al.[19]	RS	26	17	26	0	TS	SC	MPRS	15/24	NA
15	2018	Yu et al.[20]	RS	62	34	29	21	TE	SC	MPRS	16/24	NA
16	2019	*Chen et al.[21]	RCT	24	11	5	3	TC	Log MAR	MPRS	NA	3/5

RS, retrospective study; NRCT, non-randomised controlled trial; NRPS, non-randomised prospective study; RCT, randomised controlled trial; TE, transethmoidal; TCon, transconjunctival; TE, transethmoidal; NM, not mentioned; TC, transcranial; MP, multiple protocols; SC, Snellen chart; VEP, visual-evoked potential; LR, Landolt's ring; ND, not defined; DMS, dexamethasone; PRS, prednisolone; MPRS, methylprednisolone; MS, minors score; JS, Jadad score.

*studies included in NLP (no light perception) data analysis.

Test for publication bias is represented in Figure 3A, which suggests significant publication bias in included studies.

The patients in whom SC could not be used are assessed by a very basic method of assessment and grading as NLP (no light perception), PL (perception of light), HM (hand movement) and FC (finger counting). Any improvement in the visual acuity over and above NLP has been reported as an improvement by all authors. Six authors mentioned the treatment results separately in patients with NLP who have the worst possible vision after TON.

A second meta-analysis on patients with NLP was performed to compare the effect of surgical decompression (SD) and steroid therapy (ST). Here, any improvement in vision above and over NLP was taken as a positive event. There was a 46% (28/60) improvement in patients with NLP treated surgically compared to only 25% (13/51) who recovered from NLP when treated with steroid therapy (Table 3).

Meta-analysis of 6 studies in patients with baseline worst visual acuity of NLP (no light perception) on the first presentation revealed overall heterogeneity I^2 = 48% (Figure 4).

The meta-analysis of the odds ratio revealed an overall heterogeneity I^2 = 48%, which mandated a fixed-effect model suggesting statistically no significant difference between SD and ST (P = .05).

Funnel plots for studies included in the meta-analysis of patients with NLP represent no significant publication bias which was within acceptable limits (Figure 3B).

Analysis of specialities involved in management: An analysis of the specialities reported in the TON papers

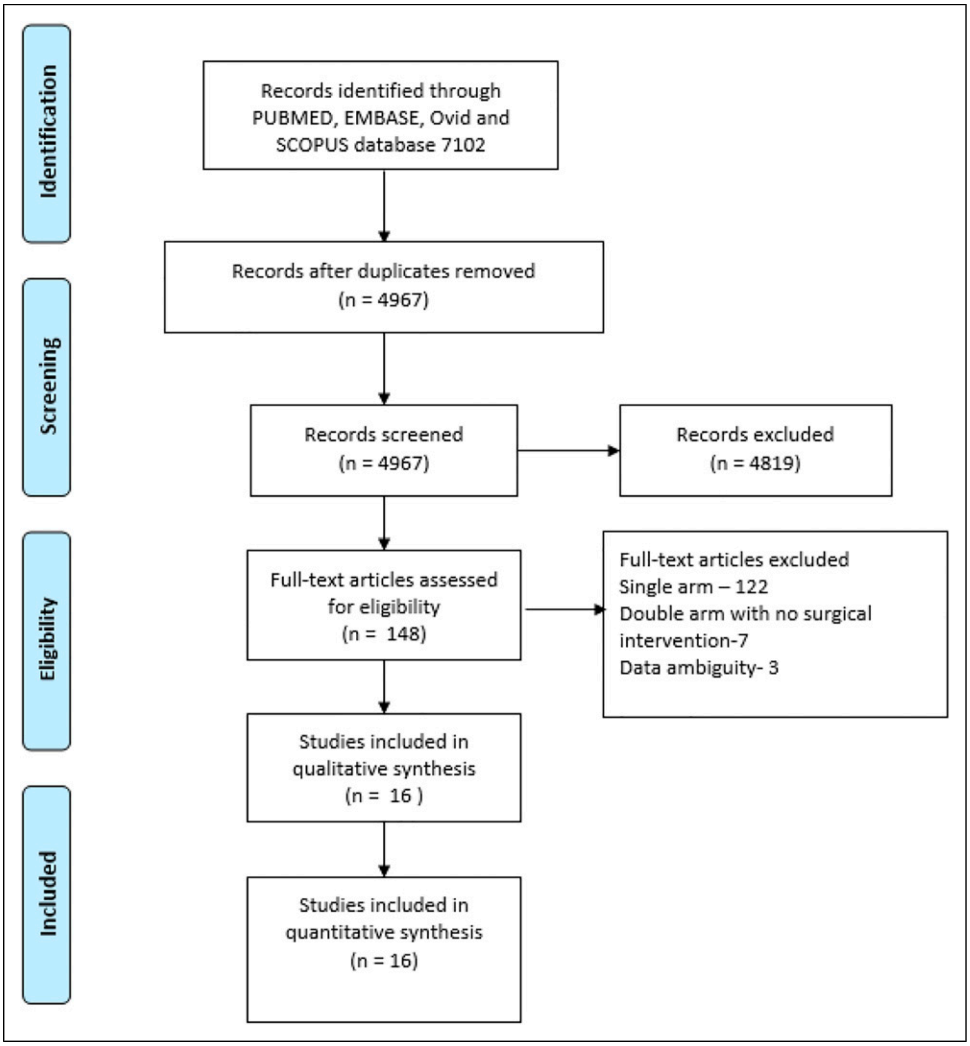

Figure 1. Prisma flow chart of a systematic review. A total of 7102 articles were selected for screening, and 148 articles were shortlisted for full-text screening. Sixteen papers were included for data synthesis and analysis.

Table 3. Studies With Data on Patients With NLP After TON.

Year	Author	NLP treated with SD	NLP cases improved with SD	Treated with ST	Improved with ST
1992	Mauriello et al.[10]	6	4	6	0
1996	P. I. Chou et al.[1]	20	9	8	2
1999	Levine et al.[11]	18	8	20	8
1999	S. Mine et al.[12]	4	2	8	0
2006	Shibuya et al.[2]	6	1	5	3
2019	Chen et al.[21]	06	4	4	0

reveals the primary involvement of ophthalmology, neuro-ophthalmology and ophthalmic plastic surgery disciplines. There is also active involvement of neurosurgery, especially in an Indian population–based case series conducted by Mahapatra et al that includes 800 patients,[22] which has not been included in the review due to non-compliance with inclusion criteria. In addition, there is an increasing role in skull base surgeons, a sub-speciality of ENT surgeons involved by the virtue of their endoscopic surgery skills.

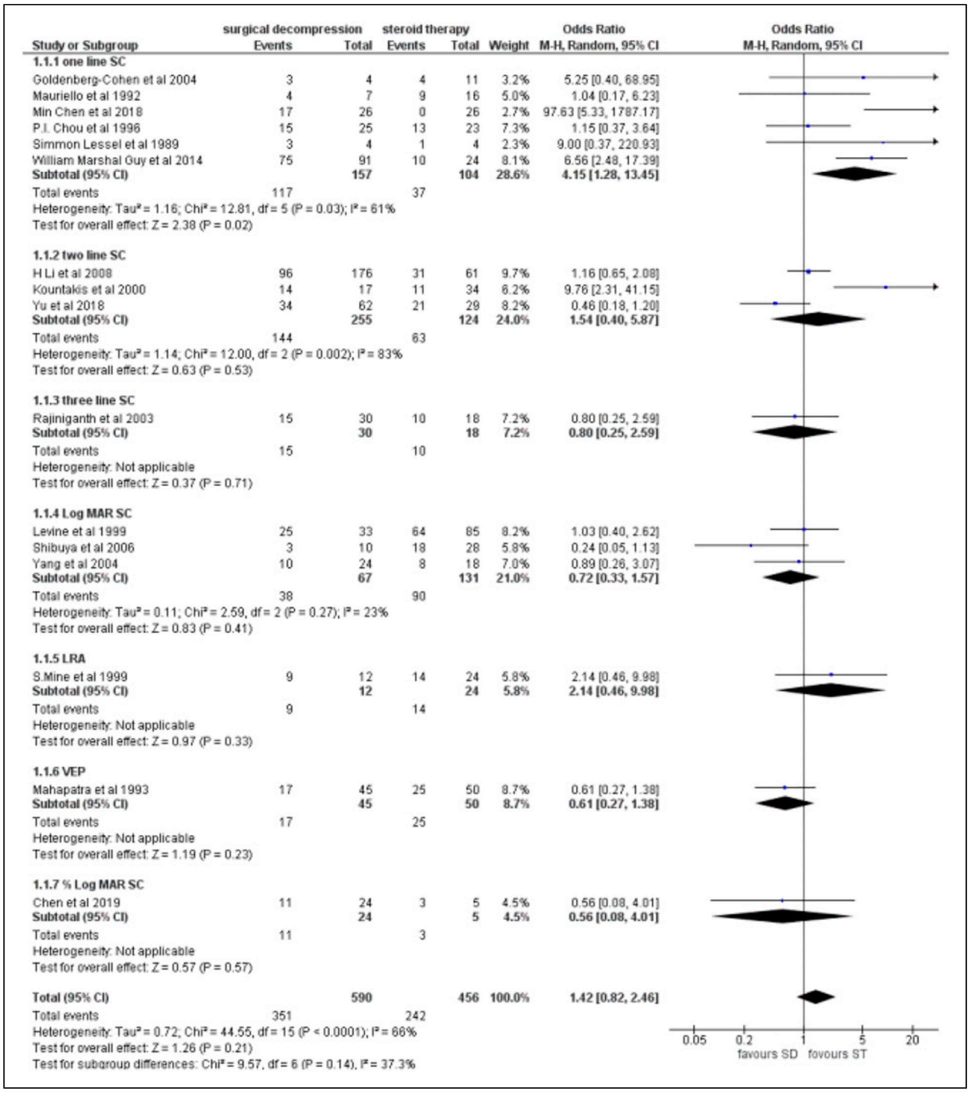

Figure 2. Forest plot with sub-group analysis comparing surgical decompression to steroid therapy among all 16 studies.

Discussion

Summary of evidence: The above presented systematic review highlights the meta-analysis using 16 studies involving 1046 patients of TON whose response to SD and ST was compared. The meta-analysis findings suggest no significant difference in the treatment results of TON patients treated with either SD or ST. A sub-group analysis has revealed no significant difference in the sub-groups based upon methods of visual acuity assessment. There was no significant difference in treatment outcomes in the group of patients with NLP either.

Sub-group analysis, however, reveals when a lower threshold criterion of one-line improvement in SC is used, treatment results favour ST. This result highlights the effect of improvement criteria with lower threshold on treatment results.

The findings of the study are in contrast to an earlier reported meta-analysis on the same topic by Rafael et al,[23] who concluded that surgical decompression is a better treatment modality in TON, and the earlier, the better results. However, the study included a lesser number of the patient as well as studies and failed to address heterogeneous methods of visual acuity assessment. This meta-analysis includes only well-designed RCT reported to date on the subject by Chen et al,[16] and our findings concur with Chen et al. that there is no statistically significant difference between the treatment strategy (SD/ST). In the light of the above findings, there is a need to further understand the mechanisms of both therapies and the possible consequences for the same. The selection of the best therapy can be guided by understanding the following important treatment aspects.

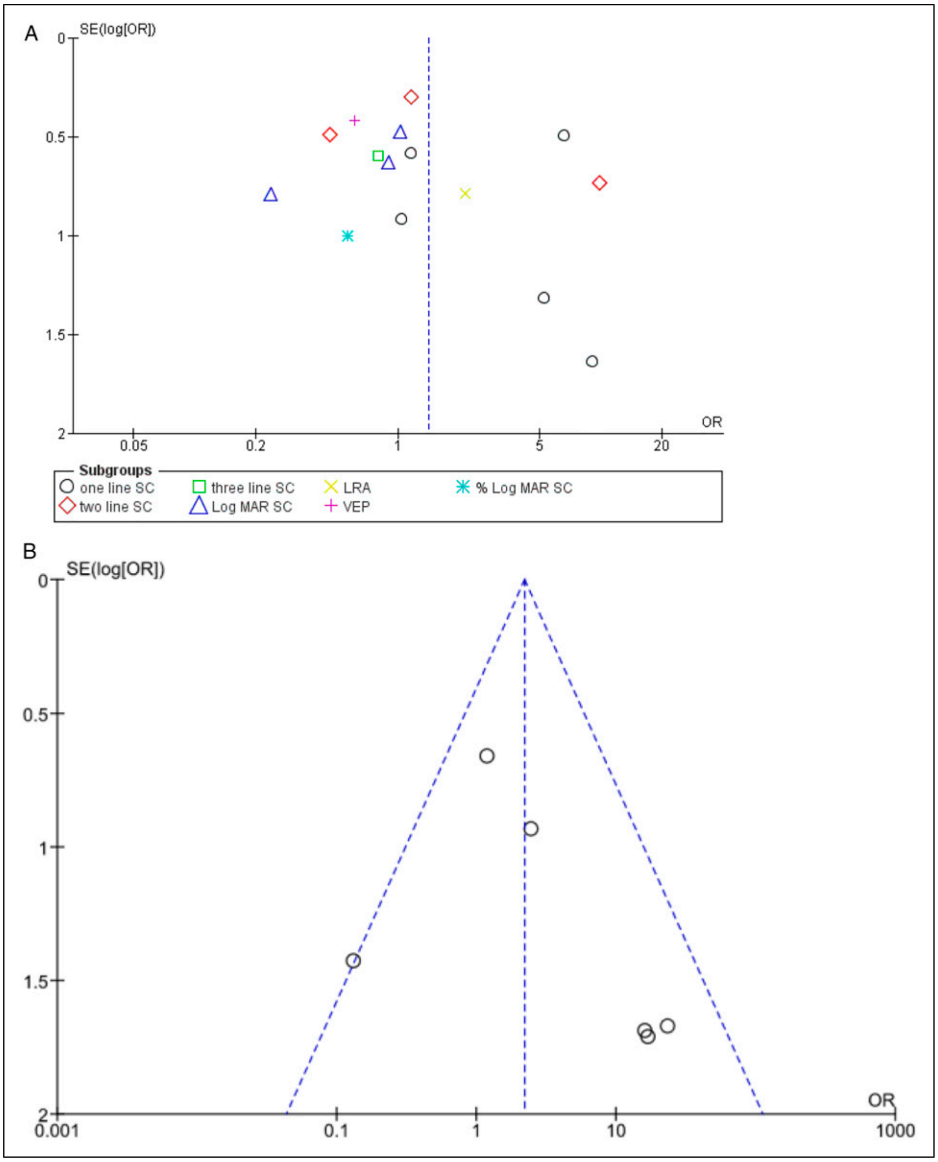

Figure 3. A. funnel plot of all studies included in the meta-analysis. B. Funnel plot for six studies in the NLP cohort meta-analysis.

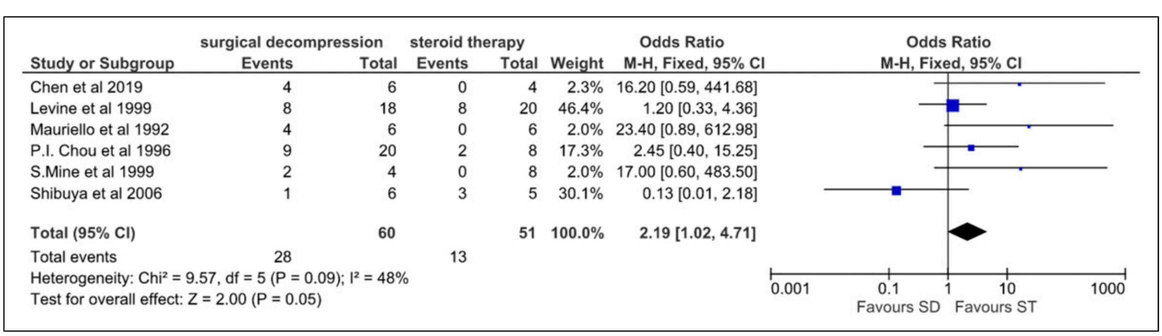

Figure 4. Forest plot comparing surgical decompression to steroid therapy among six studies involving patients with NLP.

Steroid-Mechanism of Action and the Safe Dose

Several experimental studies have shown an anti-oxidant and neuroprotective role of high-dose corticosteroids in preventing injuries from free radicals that form after injury.[24,25] As a result, the production of prostaglandins is reduced, and circulation is preserved, ultimately containing nerve cell death. However, the dose of steroids used has become a matter of concern in the backdrop of corticosteroid randomisation after a significant head injury trial in 2004[26] revealed increased mortality with high-dose corticosteroid-treated patients with a substantial head injury. Hence, there is a renewed debate over the safety of steroids since most patients with TON will have a head injury. Thus, the treatment's safety for doing no further harm becomes a priority. When reviewing the dosage of the steroids used in our review, we found that 8 out of 16 authors have reported using methylprednisolone in their protocol (Table 2). In addition, the use of megadose is mentioned in 4 studies.[2,27-29] Most importantly, three studies have reported the use of megadose even after a worldwide debate over the safety of megadose after a significant head injury trial in 2004.

The term 'megadose' is commonly used by ophthalmology which is equivalent to 'high dose' from neurology. These terms have been used to document the treatment protocol of intravenous methylprednisolone used in the management of acute spinal cord injury in second and third national spinal cord injury studies[15,18] (NASCIS II and NASCIS III) – A loading dose of 30 mg/kg followed by a continuous intravenous infusion of 5.4 mg/kg per hour for 24 or 48 hours.[14]

Animal model trials of different dosages have found the dose-dependent neuroprotective effect of methylprednisolone with interference in high doses. However, a 1 mg/kg dose did not interfere with the neuroprotective effect (14). The absence of data on a safe amount will not justify any human trial as it will be ethically not feasible.

The dosage duration is also suggestive of the observation time to assess the response to the treatment, which varied from 3 days to 3 weeks.[4] The lack of a reasonable level of evidence or difficulty in doing a randomised controlled trial can be explained by the lack of a defined dose in the international optic nerve trauma study published in 1999. Duration of 72 hours of observation after starting steroid therapy for improvement in vision was the most common protocol.[10,11,21,28,29]

Thus, the evidence for correctly titrated safe dose and its duration remains controversial as observed from trials comparing surgical decompression with steroid therapy. Nevertheless, the credible evidence of the MRC CRASH trial[13] should not be overlooked, and informed consent of increased mortality should be taken before starting a high dose of methylprednisolone.[14]

Surgical Decompression Protocols and Techniques

The literature review is evident about the first use of steroids followed by surgery of patients not responding to medical management (Table 4). However, an RCT reported by Chen et al[16] in 2019 allotted patients to different treatment groups after due consent. However, the study did not rule out even post-surgery use of steroids. The most commonly used protocol is steroid therapy for three days, followed by reassessment and surgical decompression of non-responders to medical treatment. The improvement criteria are another factor that needs to be addressed and made homogeneous. The international collaboration failed in terms of uniformity of protocol or standards for improvement assessment.[12] While few published protocols dictate the terms of application in this treatment modality, the association of NLP at presentation has usually been considered a poor prognostic factor, as reported by Mauriello et al in 1992.[20]

Evolution of Surgical Decompression Techniques

The techniques and results have understandably evolved. The transcranial approach is less preferred than the endoscopic transethmoidal approach (Table 2). However, recent literature still finds mention of the transcranial approach as recently as 2019.[16] Irrespective of the approach, the treatment is based upon relieving annular strangulation and releasing the nerve from the bony confines of the optic canal to prevent haematoma or oedema from compressing the nerve. With the advent of the endoscopic minimally invasive technique,[27] surgery appears to be an appropriate treatment option in a polytrauma patient who has to be shifted to operative room for other complications. However, the decision to use surgical decompression cannot be justified until the true incidence of spontaneous visual recovery and the contributing factors are studied.[14] This systematic review of the literature suggests that a non-responsive or progressively deteriorating vision under steroid treatment has been subjected to surgical decompression. But, the choice of steroid therapy is controversial in presence of severe head injury.

Optic Canal Fracture and Treatment Protocol

The presence of direct evidence of optic canal fracture has been considered an important prognostic factor by many authors.[28] In contrast, the largest cohort of TON from the Indian population[22] has suggested optic canal fracture as a non-significant prognostic fracture. However, the radiographic evidence of optic canal fracture remains inconclusive because few studies have reported intra-operative findings of optic canal fracture without any radiological evidence; hence, this factor cannot be dependable.[9] The literature also finds mentions of the protocol of no

Table 4. Criteria of Patient Selection for Surgical Decompression.

1989	Simmon Lessel et al.[9]	No specific protocol
1992	Mauriello et al.[10]	24–72 hours of steroid and then surgery
1993	Mahapatra et al.[4]	Three weeks of steroid therapy and then assessment
1996	P.I. Chou et al.[1]	No specific protocol was mentioned for case selection
1999	Levine et al.[11]	No specific protocol was mentioned for case selection
1999	S.Mine et al.[12]	No specific protocol was mentioned for case selection
2000	Kountakis et al.[13]	48 hours of steroid therapy and then assessment
2003	Rajiniganth et al.[14]	I. 72 hours of a steroid without improvement II. Progressive visual loss III. Total blindness with CT evidence of nerve compression
2004	Yang et al.[15]	Three days of steroid if there is no improvement and then decompression
2004	Goldenberg-Cohen et al.[16]	No specific protocol was mentioned for case selection
2006	Shibuya et al.[2]	Steroid therapy and surgery for non-responding cases, but the observation threshold is not mentioned
2008	H Li et al.[17]	No specific protocol was mentioned for case selection
2014	William Marshal Guy et al.[18]	Three days of steroids and then assessment for surgery
2018	Min Chen et al.[19]	No specific protocol was mentioned for case selection
2018	Yu et al.[20]	Three days of steroid therapy and then re-assessment
2019	Chen et al.[21]	Upfront surgery after randomised treatment allotment

intervention, which lacks support or evidence in the absence of any discussed treatment protocol or indication.

Indications for Surgical Decompression

Rajiniganth et al[28] has described three indications for surgical decompression as follows:

(I) 72 hours of steroid without improvement.
(II) Progressive visual loss.
(III) Total blindness with evidence of optic nerve compression on computed tomography.

The indications for surgical decompression remain widely debated (Table 4). However, the safety of steroid dosage in patients with significant head injury appears to make surgery a safer option, especially in patients with polytrauma who have to undergo surgery in GA (general anaesthesia) for other associated injuries. Nevertheless, the threshold of 3 days or 72 hours remains the most commonly followed protocol.[17,20,28,29]

Criteria for Assessment of Visual Acuity Improvement

The most significant factor that affected the data synthesis is the subjective nature of visual acuity assessment, especially in patients in the emergency room and their differing levels of consciousness. Mahapatra et al[4] have successfully demonstrated the use of visual-evoked potential in unconscious patients. Uncooperative children are also a challenge for clinicians to document the visual acuity (VA) upon presentation. Goldenberg and Cohen et al[30] have used relative afferent pupillary defects in uncooperative children. The most homogeneous data, which is common to all included studies, is the use of VA status as no light perception (NLP), perception of light (LP), hand movement (HM) and finger counting (FC). Hence, the data extracted in terms of NLP, LP, HM and FC becomes essential. However, it is disappointing that there is a scarcity of comprehensive data about patients in recently reported studies. Snellen's chart remains the most commonly used visual chart,[31] with its fractions converted to Log MAR (Log minimum angle of resolution) values. Newer studies have used a 'degree of improvement' (calculated from Log MAR) as a reporting tool.[8]

Limitations of Study and Scope of Improvements for Further Research

The review of literature could identify only one RCT; other studies are non-randomised prospective or case series. Assessment of primary outcome, that is, improvement in visual acuity, is difficult since different criteria are used. The authors also discovered that values of minimal vision in Snellen chart are not same for all the authors. The vision beyond 20/800 has been categorized in terms of CF, HM, PL and NLP by Shibuya et al,[2] where authors like William Marshal Guy et al[21] have used 20/400 as the minimal acuity beyond which vision was defined in terms of CF. The extraction of data, that is, improvement of vision, was reported in terms of criteria used by all the authors which was not uniform. The authors have thus used a separate meta-analysis of patients with NLP as baseline pre-intervention

VA and assessed the effectiveness of ST and SD in this cohort. A sub-group analysis also investigated this heterogeneity in the study. The lack of uniformity and difficulty in generalising a single visual assessment method at the initial stage makes the comparison of studies difficult. We could identify that the data on severity of associated head injuries, that is, traumatic brain injury, sub-dural haematoma and anterior skull base fractures, were missing. The literature review lacks documentation of associated craniofacial fractures except for a few studies. The low incidence of this complication with the abovementioned limitations was reflected in the results of international collaboration optic nerve trauma study[12] with non-uniform protocols of ST and surgical intervention.

Conclusion

The meta-analysis concludes that there is no significant difference in SD and ST in terms of improvement in visual acuity. Patients with the worst pre-treatment vision of NLP also do not differ in their response to either SD or ST. The meta-analysis highlights the importance of uniform initial and follow-up visual assessment methods, the need for proper documentation of complications, the severity of associated head injuries and even the death of patients with an associated head injury. There is a need for proper speciality reference among various specialities and timely intervention to decrease the poor prognosis of vision in cases of TON (traumatic optic neuropathy).

Author Contributions

SP: Concept of study design, research question, data synthesis and interpretation. GR: Data synthesis and interpretation. AC: Data synthesis and interpretation. AD and BR: Proofreading.

Declaration of Conflicting Interests

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Abbreviation

TON	traumatic optic neuropathy
VA	visual acuity
NLP	no light perception
LP	light perception
HM	hand movement
FC	finger counting
SC	Snellen chart
Log MAR	Log minimum angle of resolution.