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ORIGINAL ARTICLE

Surgical management of recurrent TMJ dislocation—a systematic review

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Abstract

Purpose Recurrent temporomandibular joint (TMJ) dislocation can be challenging to treat and the current understanding regarding aetiology and management of this condition is limited. The aim of this paper was to conduct a systematic review regarding the management of recurrent TMJ dislocation.

Methods A literature review was conducted using PRISMA guidelines to identify papers published between 2006 and 2016. The resultant papers were analysed.

Results A total of 33 papers were found relevant to the study. Minimally invasive techniques described included autologous blood injection, which was associated with an overall success of 80% at 12 months. Other modalities investigated included OK-432 sclerotherapy, laser capsulorrhaphy, botulinum toxin of the lateral pterygoid muscle or modified dextrose. These publications show promising success rates.

Surgical techniques described included disc plication, eminoplasty and eminectomy. These modalities had a similar success rate, although numbers were limited. The true incidence of recurrent TMJ dislocation is unknown and aetiology is limited to expert opinion.

Conclusion The current understanding of management for recurrent TMJ dislocation is limited to case series and case reports. This paper compiles the current understanding of management of recurrent TMJ dislocation. Compared to previous reviews, this paper describes some novel minimally invasive techniques with promising success in the management of recurrent TMJ dislocation.

Keywords Temporomandibular Joint · Eminectomy · Disc Plication · Botulinum toxin, eminoplasty · Dislocation

Introduction

Recurrent temporomandibular joint (TMJ) dislocation can be debilitating for patients and challenging with regards to diagnosis and management for practitioners.

Dislocation of the temporomandibular joint causes significant pain and anxiety for patients, and results in trauma to the joint capsule and ligaments. This dislocation may occur in one of four forms. The first form, subluxation, occurs when there are transient partial dislocations of the TMJ that are usually self-resolving. The second form, acute dislocation, usually occurs as a result of trauma or excessive mouth opening (e.g. during yawning or after prolonged dental procedures [1]). Acute TMJ dislocation is managed via manual reduction, which may require sedation. This may be augmented with supportive bandages and soft diet. The third form, chronic dislocation, occurs when there is prolonged disarticulation of the TMJ, usually as a result of underlying laxity of the joint capsule. This may be secondary to age-related degeneration, an inherent connective tissue disorder (such as Ehler's Danlos Syndrome [1]), or as an adverse effect of antipsychotic medication such as clonazepam [2]. Chronic dislocation may be managed conservatively via positional devices, or surgically. The last form of TMJ dislocation is recurrent dislocation. This occurs when there are recurrent acute episodes of TMJ disarticulation due to either joint capsule/ligament laxity, anatomical variation in the joint or dystonia of the lateral pterygoid muscle causing spasmodic antero-medial pull on the condylar head. The four forms of TMJ dislocation are discrete in their mechanisms, and it is important to differentiate them clinically, as their approach to

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treatment differs. Patients may have features or risk factors of more than one type of dislocation. Ideally, the type and risk factors for dislocation should be identified so that treatment can address the mechanism of dislocation.

Recurrent TMJ dislocation and its treatment are not well understood [3]. Treatment modalities described for the management of recurrent TMJ dislocation in the literature can be classified as minimally invasive or surgical. In general, conservative methods are trialled before surgical management. Currently, there is no ideal treatment guide with which to approach recurrent TMJ dislocation [4]. The aim of this study was to undertake a systematic review of current concepts regarding clinical management of recurrent TMJ dislocation. This is especially important as recently, newer treatment modalities for recurrent TMJ dislocation are emerging.

Materials and Methods

Using PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses [5]), a search was carried out with the MESH terms "recurrent" "temporomandibular joint" and "dislocation", over the last 10 years (2006–2016) using the databases PubMed (MEDLINE), Cochrane Library and Science Direct. Inclusion criteria were studies involving patients with recurrent TMJ dislocation, undergoing either minimally invasive or surgical management, where minimally invasive treatment includes intra-articular injection of blood or sclerosing agents. A total of 64 papers were found using the above terms. Papers not relating directly to recurrent TMJ dislocation or those papers not available in English were excluded (Fig. 1). This left a total of 38 papers for analysis, 33 clinical papers relating to either minimally invasive techniques or surgery and five regarding the aetiology or overview of TMJ dislocation. The papers were reviewed in relation to patient demographics, aetiology of TMJ dislocation, management and outcomes (recurrence of dislocation).

Results

A total of 33 clinical papers were found to be suitable for the basis for this review of recurrent TMJ dislocation in the last 10 years. Of these, only one paper was of level I evidence (systematic review or meta-analysis), 4 were level II evidence (randomised clinical trials), 6 level III evidence (retrospective cohort studies), 14 level IV evidence (case series), and 8 level V evidence (case report or expert opinion). The longest period of follow-up was up to 12 years. However, when assessing surgical management of recurrent TMJ dislocation specifically, the evidence was not as strong, with no level I evidence, and only one prospective cohort study. The majority of literature on surgical management of recurrent TMJ dislocation was limited to case series or case reports.

Papers relating to overviews or opinion

Aetiology and incidence

The incidence of recurrent TMJ dislocation has not been described, although it is thought to be more often associated with females with pre-existing joint disease, and perhaps neuromuscular disorders.

The true aetiology of recurrent TMJ dislocation is also poorly understood. The aetiology of recurrent TMJ dislocation can be based on either anatomical factors or functional factors. Murakami [6] described synovial plicae in 62.5% (18 of 28) TMJs undergoing surgery for recurrent dislocation. The role of the plicae in recurrent TMJ dislocation is not understood, but could potentially be a contributor. On the other hand, it could also be an iatrogenic sequelae of previous attempts to treat the recurrent dislocation.

Liddell considered functional factors that may contribute to recurrent TMJ dislocation. He suggested that connective tissue disease such as Ehler's Danlos Syndrome [7] can be attributed to recurrent TMJ dislocation as a result of increased joint laxity. Furthermore, muscular dystonias resulting in insufficient joint support from the masticatory apparatus can also result in recurrent dislocation [7]. Neurodegenerative disease such as Parkinson's and Huntington's can cause muscular dystonia, thereby resulting in recurrent TMJ dislocation [7]. These factors predisposing to recurrent dislocation are speculation only, as the incidence of recurrent TMJ dislocation in patients with each condition is not known to be higher than the overall population.

Investigations

No papers were found assessing the sensitivity or specificity of investigations for recurrent TMJ dislocation specifically. In general, OPG (orthopantomogram) X-ray is used as a general screening tool, and may depict abnormal bony morphology of the condylar head. Sahoo [8] used OPG to assess post-operative changes in the articular eminence form after Dautrey's procedure. This study found that the average height of the pre-operative articular eminence was 7.49 mm on the right and 7.32 mm on the left in patients with recurrent TMJ dislocation. There was no comparison to the general population.

CT and MRI are used in investigation of TMJ disease in general, but their use in investigating the cause of recurrent TMJ dislocation is unknown.

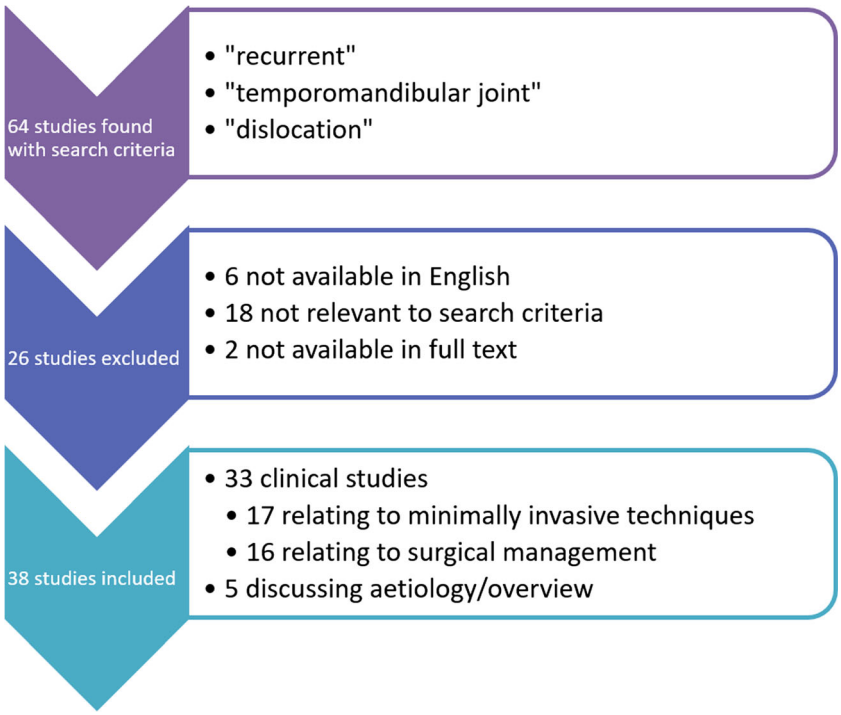

Fig. 1 Papers included and excluded in study

Treatment options

The management of recurrent TMJ dislocation should be personalised to the patient [9], with some reference to the hypothesised aetiology for that particular patient. Treatment should have a sequential approach, with minimally invasive modalities trialled before surgery is undertaken, unless a localised pathology is identified.

In general, management of recurrent TMJ dislocation is based on one of three aims. The first of these is to induce fibrosis within the peri-articular tissues. This may be via autologous blood injection, capsulorrhaphy or OK-432 sclerosing agent.

The second aim of treatment is to remove the obstruction to joint relocation. This is largely achieved via eminectomy. The third goal of treatment of recurrent TMJ dislocation is to limit anterior joint translation. This can be achieved by methods such as mini-anchor, eminoplasty or inactivating the lateral pterygoid muscle.

Treatment modalities aimed at limiting jaw joint movement need to be combined with a period of post-operative limitation of mouth opening. This should be followed by some physiotherapy to prevent joint ankylosis [10]. Undt [10] suggested in his review paper of eminectomy that surgical options for recurrent TMJ dislocation should only be considered once minimally invasive techniques have been trialled and failed.

Contraindications to eminectomy or eminoplasty include high surgical risk due to patient co-morbidities or pneumatisation of the articular eminence as seen on CT or MRI imaging [9].

Efficacy of treatment

De Almeida conducted a systematic review on the management of recurrent temporomandibular joint dislocation [4]. This study found that there is no good quality evidence on efficacy of different treatment modalities. The study also suggested that some surgeons opted for eminectomy in cases where other treatment modalities had failed. This suggested that although evidence is not robust, eminectomy may be perceived as the gold standard for recurrent TMJ dislocation.

Papers discussing specific treatment modalities

Of the 33 papers describing treatment modalities for recurrent TMJ dislocation, 17 referred to minimally invasive techniques (Table 1) and 16 referred to surgical management (Table 2)

Minimally invasive treatment

Minimally invasive methods include intermaxillary fixation, injection of botulinum toxin A into the lateral pterygoid muscle, as well injections into the joint space. Materials injected into the joint space included autologous blood, modified dextrose [24] and OK-432 [25].

Botulinum toxin A injection of the lateral pterygoid muscle

Botulinum toxin A injection into bilateral lateral pterygoid muscles has been shown in two case reports [3, 22] to alleviate recurrent TMJ dislocation without recurrence at up to 6 months. Oztel and colleagues [3] described a case of a 99-

Table 1 Minimally invasive management of recurrent TMJ dislocation

Reference number	Authors	Year	Journal	Type	Case number	Modality	Follow-up (months)
[11]	Coser	2015	IJOMS	Case series	11	Blood	35
[12]	Bayoumi	2014	IJOMS	Case series	15	Blood	12
[13]	Hegab	2013	BJOMS	RCT	48	Blood	12
[14]	Machon	2009	JOMS	Case series	25	Blood	12
[15]	Kato et al.	2007	J Oral Sci	Case report	1	Blood	5
[16]	Gupta	2013	J Oral Biol Craniofac Res	Case report	1	Blood	8
[17]	Gulses et al.	2013	J Craniomaxillofac Surg	Clinical trial (animal)	16	Blood	1
[18]	Candirli et al.	2012	Imaging Sci Dent	Prospective	14	Blood	1
[19]	Candirli et al.	2011	J Craniofac Surg	Clinical trial (animal)	8	Blood	1
[20]	Pinto	2009	JOMS	Case series	1	Blood	12
[21]	Daif	2010	OOOOE	RCT	30	Blood	12
[3]	Oztel et al.	2016	BJOMS	Case report	1	Botox	6
[22]	Vazquez et al.	2010	OOOOE	Case series	4	Botox	7
[23]	Torres	2012	IJOMS	Case series	11	Electrothermal capsulorraphy	27
[24]	Zhou et al.	2014	BJOMS	Retrospective review	45	50% dextrose	12
[25]	Matsushita et al.	2007	BJOMS	Case series	2	OK-432	6

BJOMS, British Journal of Oral and Maxillofacial Surgery; *IJOMS*, International Journal of Oral and Maxillofacial Surgery; *OMS*, Oral and Maxillofacial Surgery; *Pediatr Dent*, Pediatric Dentistry; *J Oral Biol Craniofac Res*, Journal of Oral Biology and Craniofacial Research; *J Craniomaxillofac Surg*, Journal of Cranio-Maxillo-Facial Surgery; *Imaging Sci Dent*, Imaging Science in Dentistry; *J Craniofac Surg*, Journal of Craniofacial Surgery; *OOOOE*, Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, Endodontology; *J Laryngol Otol Suppl*, Journal of Laryngology and Otology Supplement; *JOMS*, Journal of Oral and Maxillofacial Surgery; *J Oral Sci*, Journal of oral science

year-old woman who presented to a regional centre with bilateral recurrent TMJ dislocation. She was initially treated with manual reduction and IMF, which she did not tolerate. She was then treated with 25 units of botulinum toxin diluted in 2 ml 0.9% normal saline. The lateral pterygoids were injected trans-cutaneously via the sigmoid notch. There was no recurrence at 6 months. Vazquez et al. [22] described four cases of recurrent TMJ dislocation, all of which were thought to be neurogenic in origin with the predisposing conditions being traumatic brain injury, Alzheimer's disease, Parkinson's disease and myotonic dystrophy. The mean follow-up period was 7 months, with one patient suffering recurrence, and another patient requiring two doses of botulinum toxin. Thus, undertaking the present systemic review revealed five cases where botulinum toxin was used in the lateral pterygoid muscle to alleviate recurrent TMJ dislocation, with a combined success of 80% (4 of 5) at 6 months.

Autologous blood (ABI) into joint space Injection of autologous blood into the superior joint space and into the joint capsule has been discussed in multiple case series, and has been associated with up to 80% success rate in alleviating recurrent TMJ dislocation at 12 months [11, 12, 14, 16].

Bayoumi and colleagues described a case series of 15 patients, all who underwent bilateral injections of autologous blood, 2 ml into the superior joint space and 1 ml into the pericapsular tissues [12]. The patients were followed up for 12 months, and 80% (12 of 15) had no recurrence. Those who suffered recurrence of their dislocation did so early, at a mean of 3 weeks post procedure. Similarly, Coser et al. assessed the efficacy of ABI [11] in a cohort of eleven patients who received bilateral ABI for recurrent TMJ dislocation. Over a mean follow-up period of 30 months, 73% (8 of 11) had no recurrence.

A further study reported 25 patients with bilateral TMJ dislocation who underwent ABI and were followed up for a mean of 12 months [14]. Within 4 weeks, the success rate was 60% (15 of 25) [14]. The remaining 10 patients underwent a second treatment at this stage and at 12 months, 80% of patients (20 of 25) had no recurrence of their dislocation after either one or two treatments. Single case reports of this technique have also been published, with one of an 82-year-old man who underwent bilateral ABI for recurrent TMJ dislocation, with no recurrence at 8 months [16], another of an 84-year-old patient was treated successfully for recurrent TMJ dislocation with ABI, showing no clinical recurrence at

Table 2 Surgical management of recurrent TMJ dislocation

Reference number	Authors	Year	Journal	Type	Case number	Modality	Follow-up (months)
[1]	De Freitas Silva et al.	2016	J Craniofac Surg	Letter to Editor	1	Disc plication	12
[26]	Zachariah et al.	2015	JOMS	Case series	17	Disc plication	12
[27]	Pentyala et al.	2014	J Craniofac Surg	Case report	1	Eminectomy	Not specified
[28]	Martins	2014	Cranio	Case report	2	Eminectomy	12
[29]	Mayrink	2012	J Craniofac Surg	Case series	3	Eminectomy	60 (5 years)
[30]	Guven	2009	J Craniomaxillofac Surg	Retrospective	19	Eminectomy and eminoplasty	12–144 (1–12 years)
[31]	Kahveci et al.	2013	JOMS	Retrospective analysis	73	Eminoplasty	30
[32]	Da Costa Ribeiro	2014	IJOMS	Case series	2	Eminoplasty	12–24
[33]	Ying et al.	2013	J Craniofac Surg	Case series	7	Eminoplasty	24
[8]	Sahoo	2013	JOMS	Case series	10	Eminoplasty	12
[34]	Gadre	2010	JOMS	Retrospective	20	Eminoplasty	36
[30]	Guven	2008	J Craniofac Surg	Case series	12	Eminoplasty	48 (mean 4 years)
[35]	Guarda-Nardini et al.	2008	Oral Maxillofac Surg	Case report	1	Eminoplasty	8
[36]	Medra et al.	2008	BJOMS	Prospective study	60	Eminoplasty	12–96 (8 years)
[37]	Taglialatela	2012	J Craniofac Surg	Case series	7	Orthognathic surgery	12

J Craniofac Surg, Journal of Craniofacial Surgery; *JOMS*, Journal of Oral and Maxillofacial Surgery; *Cranio*, Journal of Craniomandibular Practice CRANIO; *IJOMS*, International Journal of Oral and Maxillofacial Surgery; *J Craniomaxillofac Surg*, Journal of Cranio-Maxillo-Facial Surgery; *OMS*, Oral and Maxillofacial Surgery; *BJOMS*, British Journal of Oral and Maxillofacial Surgery

5 months [15], and a third describing a case where ABI was combined with a supportive head bandage for 4 weeks with no recurrence at 12 months [20].

The above papers described a total of 54 patients treated with ABI, with a success rate of 80% (43 of 54) at a mean follow-up of 16 months.

The technique of ABI described by most studies involves injection of 2–3 ml of autologous blood into the superior joint space (SJS), with or without injection of a further 1 ml into the pericapsular tissues (PT). Daif [21] showed that injection into both the SJS and PT was associated with a success of 80% (12 of 15) at 12 months compared to a success of 60% (9 of 15) if only the SJS was injected.

This success rate may be further increased with the concurrent use of intermaxillary fixation for 4 weeks [13]. Hegab described a study in which 48 patients with recurrent TMJ dislocation were divided equally into three groups. The first group received ABI into the SJS and PT. The second group received ABI in the same way, but were also treated with IMF for 4 weeks. The third group received IMF alone for 4 weeks. Of the 16 patients that received ABI alone, half ($n = 8$) had recurrence of TMJ dislocation. Three of the 16 patients treated with IMF alone had recurrence of dislocation. The combined ABI and IMF treatment group was associated with the best success, with none of the 16 patients suffering recurrent dislocation. However, all three treatment modalities were associated with decreased mouth opening. The mean decrease in mouth opening for ABI alone, IMF alone and combined ABI and IMF were 8.5 mm, 9.13 mm and 11 mm respectively. The difference between the ABI group and the IMF group was not statistically significant, but combined treatment with both ABI and IMF was associated with a statistically significant decrease in mouth opening when compared to the other two groups. Recurrence in the ABI only group was overcome by multiple injections. No patients had recurrence after a maximum of three injections. Recurrence in the IMF alone group was overcome with a further 2 weeks of IMF.

The mechanism of action of autologous blood injection for the treatment of recurrent TMJ dislocation was explored by Candirli et al. [19] in a laboratory study using eight New Zealand white rabbits who underwent bilateral autologous blood injection, followed by IMF for 4 weeks. This was achieved via fixation of orthodontic brackets and elastics. After 4 weeks, the animals were sacrificed and the TMJs underwent histological analysis. This showed accumulation of fibrin within the joints, without an inflammatory infiltrate or vessel proliferation. Gulses et al. [17] explored this further, when they compared histological changes in 16 pigs who underwent bilateral ABI versus those who received injection of normal saline only. Joints injected with autologous blood

were associated with fibrosis in the retrodiscal and pericapsular tissues, whereas histology of saline-injected joints appeared unchanged.

Candirli et al. in 2012 assessed MRI changes in human subjects 1 month after autologous blood injection [18]. This study of 14 subjects showed improvement in the condyle-glenoid fossa relationship 4 weeks after ABI. Specifically, open-mouth views showed the condyle either at or posterior to the articular eminence. This was in contrast to pre-operative MRI, where the condyle was found to be anterior to the eminence in open mouth views. There were no MRI findings suggesting of haematoma or structural joint change.

Modified dextrose injection into joint space Zhou et al. [24] described injection of lignocaine and 50% dextrose into the posterior periarticular tissues, as a method of inducing fibrosis in treatment of recurrent TMJ dislocation in 45 patients with recurrent TMJ dislocation, aged 17 to 59 years. Post operatively, patients were instructed to have a soft diet and avoid wide opening for 2 weeks. Patients were followed up for a mean of 18 months, with a success of 91% (40 of 45 patients). However, 27% (12 of 45) patients required a second injection, and 4% (2 of 45) patients required a total of three injections. No animal studies have been found investigating the histological changes induced by this technique.

OK-432 injection into joint space OK-432 is a group A streptococcal pyogenes derivative that has been treated with penicillin G and lyophilized [38]. It is therefore contraindicated in patients with a penicillin allergy. This agent can then be stored in 15-ml tubes containing 0.16 ml of EDTA (ethylenediaminetetraacetic acid) solution. OK-432 has been found to induce a local inflammatory response, resulting in fibrosis. OK-432 was used as a sclerosing agent into the temporomandibular joints of two patients unsuitable for surgical management [25]. The first of these patients was a 68-year-old man with supra-nuclear palsy who had been treated with bilateral injection of autologous blood that resulted in recurrence of dislocation at one month. He was subsequently treated with bilateral OK-432 sclerosing agent that successfully treated his dislocation at a follow-up of 6 months [25]. The second patient was a 91-year-old woman, also with bilateral recurrent TMJ dislocation, who was treated primarily with OK-432 bilaterally, and had no recurrence at 6 months [25]. No animal studies were found to explore the histological changes induced by OK-432.

Electrothermal capsulorraphy Stimulation of fibrosis within the TMJ with electrothermal capsulorraphy treatment for recurrent TMJ dislocation can be achieved via an arthroscopic approach and either Hol:YAG laser or electrocautery [23]. Only one study in the systematic review explored this treatment modality, and described a success rate of 82% (9 of 11 patients) with a long follow-up period of 27 months [23].

Surgical management

Surgical management of recurrent TMJ dislocations could be grouped into methods of disc plication, eminectomy or eminoplasty, orthognathic surgery or alloplastic joint replacement. Surgical methods are adopted when conservative methods have either failed or are not suitable due to patient factors.

Disc plication Disc plication using artificial anchors/ligaments was first described by Cottrell and Wolford [39]. In the setting of recurrent TMJ dislocation, Zachariah and his group [26] conducted a case series of 17 patients (27 joints) where the disc was plicated to the condylar head by using an orthodontic mini-screw placed into the condylar head and a non-resorbable prolene suture anchoring the posterior disc to the mini-screw [26]. There were no cases of recurrence of TMJ dislocation at 12 months using this technique [26].

Eminectomy Eminectomy is the removal of the articular eminence of the temporal bone, thus reducing obstruction to the relocation of the condylar head after dislocation. Eminectomy for TMJ dislocation was first described by Myrhaug in 1951 [40]. It has been reported as having 100% efficacy at up to 5 years; however, there have only been a small number of reports with small sample sizes of 3 or less [27–29]. Guven in 2009 assessed patients undergoing both eminectomy and eminoplasty, and found that eminectomy was associated with greater post-operative inter-incisal opening [30]. They reported on 19 patients with recurrent TMJ dislocation (a total of 37 joints), aged between 22 and 80 years (mean = 44) that were treated with eminectomy ($n = 9$) if they had either previously failed surgical treatment, had a systemic condition predisposing to dislocation (e.g. neurodegenerative disease) or if post-operative IMF was contraindicated [30]. All other patients in this study ($n = 12$) were treated with eminoplasty via an oblique osteotomy with inter-positional chin graft without fixation [30]. This study reported 100% success, with none of the 19 patients suffering recurrence of their dislocation over a follow-up period that was between 12 months and 12 years [30]. The only variation between the two techniques reported was that patients treated with eminectomy had a post-operative decrease in their mouth opening of 7 mm (mean), and those treated with eminoplasty had a decrease of 11.67 mm [30].

Eminoplasty Eminoplasty was first described by LeClerc and Girard as a glenotemporal osteotomy [41], and was later modified by Gosserez and Dautrey via interposition of a bone graft into a sub-periosteal pocket. This procedure involves down fracture of the zygomatic arch to increase both the vertical and horizontal dimension of the articular eminence. The position of the articular eminence has been reported to move

inferiorly by approximately 3.5 mm and anteriorly by approximately 4.5 mm [8]. Adaptations of this procedure have been described since LeClerc and Dautrey, including the incorporation of mini-plates and temporal fascial flaps [33]. More recently, blocking techniques have been described using calvarial [35], chin [42] or iliac bone grafts [31] fixated with or without mini-plates to produce an articular eminence over which the condyle cannot glide, thereby preventing dislocation. Risks of these blocking techniques include post-operative pain, infection and fracture of mini-plate [31].

In this systematic review, nine studies described eminoplasty for recurrent TMJ dislocation. Guven in 2009 [30] described 19 patients suffering from recurrent TMJ dislocation. These patients were managed either by eminectomy or eminoplasty as described above. Of the 12 patients in this study that underwent eminoplasty, none had recurrence at a follow-up of between 2 and 6 years. They did however report a decrease in post-operative mouth opening of 11.67 mm [30].

Gadre and colleagues looked at 20 patients who underwent Dautrey's procedure for recurrent TMJ dislocation, and followed them for 18 months. There was no recurrence, and a mean decrease in MMO of 7 mm post-operatively [34].

Kahveci et al. described 73 patients who were treated for recurrent TMJ dislocation with autologous bone graft fixated to the antero-inferior surface of the articular eminence with mini-plate and screws [31]. These patients were followed up between 3 and 30 months. Post-operative maximum mouth opening (MMO) was reduced to a mean of 38 mm, although pre-operative MMO was not reported. Three cases were complicated by post-operative infection or fracture of metalware. The exact recurrence rate of TMJ dislocation was not defined in the paper [31].

Da Costa Ribeiro explored surgical treatment options for patients where eminectomy was not possible due to pneumatisation of the articular eminence [32]. Two patients were treated with a modified Dautrey's procedure, where the zygomatic arch was down-fractured, and a mini-plate was applied from the lateral of the articular eminence to the displaced zygomatic arch. Both patients who underwent this procedure had no recurrence at 12 and 24 months, and had a post-operative MMO of 48 and 45 mm respectively [32].

Ying et al. also introduced a modified eminoplasty technique for recurrent TMJ dislocation [33]. Seven patients underwent a modified LeClerc blocking procedure, where two osteotomies were made along the zygomatic arch—one anterior to the articular eminence and one at the zygomaticotemporal suture. The zygomatic arch was down-fractured such that the posterior end of the segment was antero-inferior to the articular eminence. Fixation in this position was achieved via mini-plates and screws. An inferior-based temporal fascia flap was then used to plicate the antero-lateral aspect of the TMJ capsule. There was no recurrence in the study group over a follow-up period ranging from 6 to 24 months. There was a mean decrease in mouth opening of 9.8 mm. Four of the seven patients also reported improvement in TMJ pain and sounds [33].

Sahoo and colleague looked at the changes in the articular eminence dimensions after Dautrey's procedure in ten patients [8]. Dimensions were measured on OPG X-ray at 12 months, and found to have an increase in the vertical height of the eminence of 3.65 mm (average, right) and 3.52 mm (average, left), which reflects an increase of 48.73% and 48.08% respectively [8]. There was also an anterior shift of the articular eminence of 4.56 mm (average, right) and 4.51 mm (average, left). There was a mean decrease in post-operative MMO of 4.09 mm [8].

Guven in 2008 described another modification of eminoplasty. Twelve patients underwent an oblique osteotomy of the articular eminence, and interpositional autologous bone graft, which was obtained from the chin. No conventional fixation methods were used. The patients were followed up for a mean of 4.2 years, with no recurrence [42]. Guarda-Nardini also described an interpositional graft of the articular eminence, this time harvested from calvarium. In this case report of one patient, there was no recurrence at 8 months [35]. Medra looked at a larger sample size, this time of 60 patients with recurrent TMJ dislocation [36]. All patients underwent a horizontal osteotomy of the articular eminence, and interpositional autologous bone graft, wither from iliac crest or split calvarial. Fixation was either with wires, or mini-plates and screws. Patients were followed up for a mean of 36 months, with a mean post-operative MMO of 42 mm at 12 months. Five patients had temporary facial nerve paralysis, with resolution by 3 months. Three patients required removal of wire which was causing pain from impingement of surrounding tissues [36].

Orthognathic surgery Bimaxillary orthognathic surgery has been described [37] to correct dolichofacial pattern to mesofacial as a treatment modality for recurrent TMJ dislocation. This study of seven patients with class II skeletal pattern with steep mandibular plane angle and dolichofacial type, all suffering from recurrent TMJ dislocation, were treated with a combination of orthodontic and orthognathic surgery. A bimaxillary osteotomy was performed to correct the steep occlusal plane angle and correct class II skeletal relationship [37]. There was no recurrence of TMJ dislocation reported at 12-month review [37]. It was hypothesised that the correction of their hyperdivergent dentofacial deformity also corrected the recurrent TMJ dislocation by optimising the relationship between the condylar head and articular eminence.

Discussion

The aim of this study was to review the current treatment modalities available for management of recurrent TMJ

dislocation. These treatment modalities can be either minimally invasive, or surgical. Surgical treatment is aimed at either removing any obstruction to the movement of the condylar path (eminectomy) or by increasing it, thereby preventing condylar dislocation (disc plication or Dautrey's procedure and its modifications). Minimally invasive treatment includes infection of sclerosing agents in and around the TMJ, or botulinum toxin of the lateral pterygoid muscle. Since previous review articles, new sclerosing agents have been researched, with promising results.

Recurrent TMJ dislocation is not as well understood as acute or chronic dislocation [4]. Factors contributing to recurrent TMJ dislocation include dystonia of the lateral pterygoid muscle and laxity in the meniscus and lateral TMJ ligament [9]. Although usually described in middle-aged or elderly populations, recurrent TMJ dislocation can occur at all ages, including infants [43]. Recurrent dislocations can further injure the disc, capsule and TMJ ligaments, contributing to tendency for progressive internal derangement and recurrence of dislocation [10].

Search terms used in this systematic review were MESH terms "recurrent" "temporomandibular joint" and "dislocation". This aimed to capture studies on the recurrent dislocation, rather than acute dislocation, or protracted chronic subluxation. For this same reason, hypermobility was not included as a search term as this would include a broader range of TMJ disorders not specifically causing recurrent dislocation of the condylar head outside of the glenoid fossa.

Recurrent TMJ dislocation remains a management challenge for practitioners, with no ideal treatment modality. The wide variety of treatment strategies for recurrent TMJ dislocation highlights the fact that this condition is difficult to manage.

For treatment to be successful, the treatment modality needs to be tailored to address the aetiology of the recurrent dislocation. This is a challenge, as the exact aetiology of recurrent TMJ dislocation is poorly misunderstood. For example, if a lax disc is implicated, disc plication with non-resorbable sutures or a mini orthodontic screw [26] can improve the relationship between the condyle, disc and fossa subunits of the TMJ, thereby promoting synchronised movements. Alternatively, if the eminence form is implicated in the cause of recurrent dislocation, then eminectomy or eminoplasty procedures may be of benefit. Thirdly, if lateral pterygoid dystonia is causing recurrent dislocation, then lateral pterygoid myotomy or injection of botulinum toxin A into the muscle can help alleviate this problem. Identification of the aetiology of the patient's recurrent dislocation, either on history, clinical examination or imaging, has not previously been outlined. In one of the author's surgical practice (GD), patients are currently being successfully managed by eminectomy and disc plication. A lateral pterygoid myotomy is also performed if lateral pterygoid spasm or dystonia is suspected to be contributing to recurrent dislocation. Eminectomy allows free movement of the condylar head, and avoids entrapment of the condylar anterior to the eminence, thereby avoiding the need for hospital presentation for reduction. Disc plication aims to promote synchronous movement of the condylar head and TMJ meniscus, thereby reducing ligamentous injury with hypermobility.

Injection of autologous blood into the superior joint space and lateral TMJ capsule has been extensively described in the literature, with a success rate of 80% at 16 months. This is likely due to stimulation of fibrotic changes within the retro discal tissue and joint capsule based on histological studies in pig [17] and rabbit models [19] but no structural changes have been identified on MRI [18]. Efficacy is found to be higher with injection into both the superior joint space and the peri capsular tissues when compared to the superior joint space alone [21].

Botulinum toxin injection of the lateral pterygoid muscle has also been reported to have a success of 80% at 6 months. However, the transient nature of botulinum toxin implies that patients may require multiple treatment, and currently longer term, larger cohort studies are lacking.

Modified dextrose has been shown to be a promising new modality for the minimally invasive management of recurrent TMJ dislocation. A study of 45 patients reported a success of 91% at 18 months, which is higher than that reported by any other modality. If this can be replicated by other researchers then perhaps modified dextrose may surpass other treatment modalities for management of recurrent TMJ dislocation.

Current papers on minimally invasive or surgical management of recurrent TMJ dislocation do not clearly advocate for one treatment modality over the other, except that as a principal, conservative or minimally invasive treatment should be trialled first. As with any systematic review of disease management, there may be a publication bias supporting positive results. One outcome that can be directly compared between the studies is the decrease in post-operative maximum inter-incisal mouth opening (MMO). Of the studies which included sufficient statistical analysis, it was found that a decrease in post-operative MMO occurs with all treatment modalities (Fig. 2), with no one treatment modality found worse than the others.

Large sample size studies on surgical management of recurrent TMJ dislocation with long-term follow-up are lacking, as are studies exploring the use of multiple surgical modalities in the same patient (e.g. disc plication and eminectomy together). Currently, the mainstay of minimally invasive management is autologous blood injection, although the potential for modified dextrose to surpass this is possible. Botulinum toxin injection of the lateral pterygoid muscle and OK-432 have also shown good results, but not in a large enough cohort.

The mainstay of surgical management of recurrent TMJ dislocation is eminectomy. However, disc plication has also shown excellent promise, with 100% success at 12 months in a group of 27 patients. Eminoplasty can also be effective, with several modifications described. Techniques involving mini-

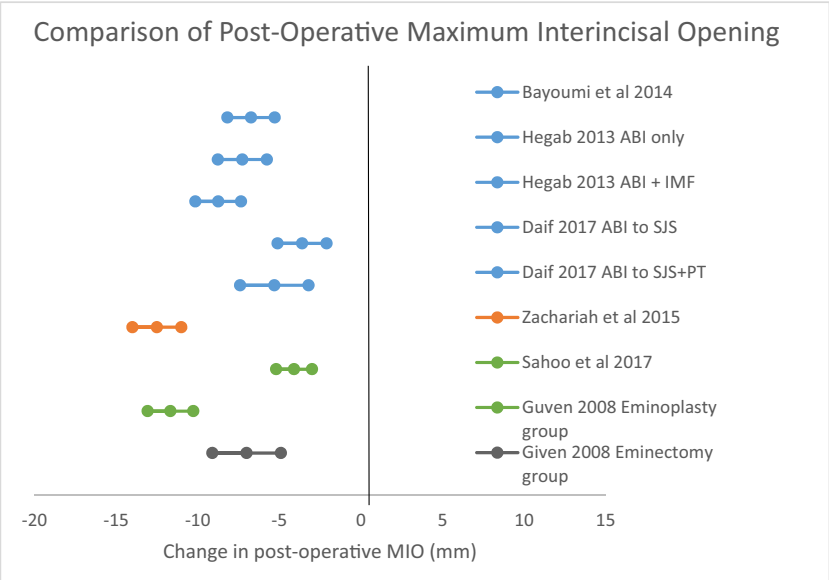

Fig. 2 Comparison of post-operative maximum inter-incisal opening. ABI, autologous blood injection; IMF, intermaxillary fixation, SJS, superior joint space; PT, pericapsular tissues; MIO, maximum inter-incisal opening

Key:

Blue	Autologous Blood Injection
Orange	Disc Plication
Green	Eminoplasty
Grey	Eminectomy

Legend:

- ABI – autologous blood injection
- IMF – intermaxillary fixation
- SJS – superior joint space
- PT – pericapsular tissues
- MIO - maximum inter-incisal opening

plates or block grafting carry with it the risk of fixation failure and donor site morbidity respectively.

Several treatment modalities have been described for the management of recurrent TMJ dislocation. The surgeon must consider the patients suitability for surgery and possible aetiology when deciding the best approach to management. Current evidence supports the trial of ABI or modified dextrose as minimally invasive management. The success of surgical approaches (disc plication, eminectomy or eminoplasty) are equivocal, and should be tailored to the patient's situation.

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Data availability Raw data and further material is available on request from the corresponding author.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest to declare.

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