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Reconstruction Of Mandibular Defects Using Transport Distraction Osteogenesis- A Systematic Review

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Abstract

This study aimed to evaluate the functional outcome, esthetics and the quality ofbone formed after transport distraction osteogenesis in mandibular defects. This was a retrospective analysis of patients who underwent mandibular transport distraction osteogenesis (TDO) for the correction of mandibular segmental defects.2 A total of 8 studies with 68 patients treated during 2000-2019. This study concluded that TDO could be used as a standard treatment protocol for mandibular defects which ameliorates the need for grafting. Future implications are that TDO studies could be conducted in a randomized controlled setting on cases such as TMJ-ankylosis, condylar agenesis/ congenital abnormalities of the condyle with a standardized patient population, better control setting and set parameters for evaluation with a longer duration of follow up. Using the principles of Distraction osteogenesis, Transport Distraction Osteogenesis works by creating an osteotomy by detaching a bone segment from one end of the defect and moving it gradually across the gap to the other end. As the bone segment is moved, the bone should form behind it, filling the defect. The new bone should have similar quality and physical dimensions to the original bone.2 The literature is saturated with information on Transport Distraction Osteogenesis; however, no review exists on the bone quality, esthetic and functional outcome of the same. The aim of this systematic review was to assess the available scientific literature regarding evaluating the functional and esthetic outcomes along with bone quality for bony defects of the mandible using Transport Distraction Osteogenesis.

Keywords: Mandibular, Defect, Reconstruction, Transport, Distraction Osteogenesis

Introduction

Distraction osteogenesis may be defined as the biological process of new bone formation between the surfaces of bone segments that are gradually separated by incremental traction.1Distraction osteogenesis was first popularized by Illzarov in the mid-20th century to correct long bone defects following which its application was extended to the distraction of the membranous bones of the craniofacial skeleton by Snyder et al. in 1973.1The mandibular distraction was further developed by Michieli and Miotti.1 They also first suggested the operative protocol in humans for mandibular distraction, which included: latency period of 1 week after osteotomy, an activation rate of 1 mm on alternate days, and a minimum consolidation period of 45 days for every 15mm of distraction.[1]

The first clinical case of Distraction osteogenesis in the human mandible was reported by McCarthy et al. in 1992. Constantino et al were the first to report bifocal distraction of the mandible by using an external custom-made distraction device to regenerate a segmental defect of 40mm. Since then, there have been rapid advancements in the field of Transport Distraction osteogenesis, which has now become an important tool for the reconstruction of composite defects.[1]Surgical treatment of extensive hard and soft tissue may leave back segmental mandibular defects. Such defects may also be a result of congenital deformities, blast injuries, high-impact trauma, or repeated surgical debridement for the treatment of chronic osteomyelitis of the mandible. Interruption of mandibular continuity results in cosmetic and functional deformity.[2]These deformities usually involve a combination of osseous and soft tissue deficiency and are among the most challenging problems in maxillofacial surgery to reconstruct. Many options are available formandibular reconstruction, including reconstruction plates, particulate bone grafts, block bone grafts and microvascular free tissue transfer. However, these involve donor site morbidity to overcome this, alternative treatments such as transport -disc-distraction osteogenesis, have gained popularity. This procedure tries to achieve a better anatomical regeneration not only of bone but also of soft tissues, reducing donor-site morbidity.[3,4]Distraction osteogenesis is one of the recent methods to restore the appearance and the physiology of the affected area. Transport Distraction Osteogenesis of the bone is a method of bone defect reconstruction that has been used in the long bones for decades.[2]

Using the principles of Distraction osteogenesis, Transport Distraction Osteogenesis works by creating an osteotomy by detaching a bone segment from one end of the defect and moving it gradually across the gap to the other end. As the bone segment is moved, the bone should form behind it, filling the defect. The new bone should have similar quality and physical dimensions to the original bone.[2] The literature is saturated with information on Transport Distraction Osteogenesis; however, no review exists on the bone quality, esthetics and functional outcome of the same.

The aim of this systematic review was to assess the available scientific literature regarding evaluating the functional and esthetic outcomes along with bone quality for bony defects of the mandible using Transport Distraction Osteogenesis.

Methods Protocol:

A systematic review of the literature was performed using the guidelines of the PRISMA statement (preferred reporting items for systematic reviews). This study was not registered.

Information sources:

A literature search was conducted using the electronic databases PubMed (National Library of Medicine, NCBI), Cochrane Central Register of Controlled Trials and Embase, to identify condylar changes in Angle class III patients after orthognathic surgery. The search included studies published between 2000-2018.

Search strategy:

The following keywords were used to build the search strategy: ("mandibular defects") AND ("Reconstruction") AND ("Transport") AND ("distraction") AND ("osteogenesis"). The search strategy consisted of the use of free-text terms in PubMed; Cochrane Central Register of Controlled Trials; and embrace; as well as medical subject heading (MeSH) terms in PubMed. A hand search of the reference lists of the identified articles was performed to reveal additional relevant articles not retrieved in the database search.

Selection of studies:

The selection of articles was conducted by two independent reviewers (AM and PW). After removing duplicates, one reviewer first screened the titles and abstracts of all identified studies to extract the papers that were not relevant to the subject of this literature review. In this case of uncertainty, the article was included anyway. The full text of the selected publications that needed further consideration was obtained and read by both reviewers, checked against pre-determined eligibility criteria. Whenever there was disagreement, a discussion and consensus procedure followed.

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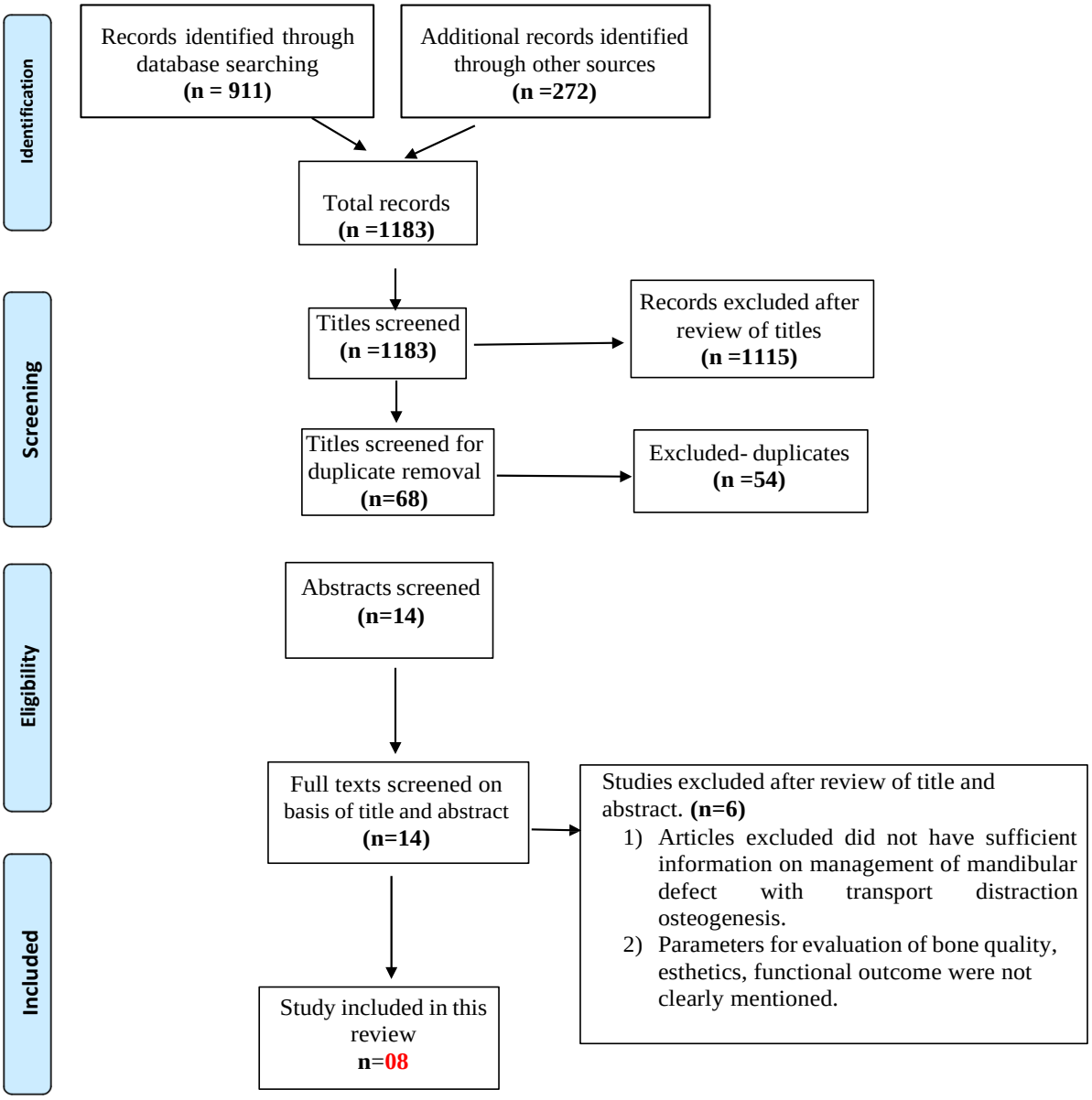
Figure 1. PRISMA flowchart: studies included and excluded during various steps.

STUDY SELECTION



Eligibility Criteria:

Articles meeting the following criteria were included:

1. Randomized clinical trials, non-randomized clinical trials, prospective study retrospective study or case series design.
2. Articles published in the English language or those having sufficient data in English on the

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reconstruction of mandibular defects using transport distraction osteogenesis.

3. Studies published between 1st January 2000 to 30th September 2019 having relevant data on the management of mandibular defects using transport distraction osteogenesis.

The Following Exclusion Criteria Were Established:

1. Literature reviews, abstracts, letters to editors, editorials and animal studies are excluded which have information on the management of mandibular defects using transport distraction osteogenesis.
2. No full text available in international databases;
3. Cases of TMJ, craniofacial and secondary deformities are excluded.

Data Collection Process:

Data from each study were independently extracted and evaluated by the two reviewers. The data recorded were first author, publication year, location, setting, patient characteristics, sample size, study design, observation period, outcome assessed and different types of reported mandibular defects.

Result:

The search yielded a total of 911 results. 272 more publications were found by a manual search of the reference lists of the identified articles. These 1115 records were screened by title and abstract. This selection procedure resulted in 68 potentially relevant articles. After removal of duplicates, 54 unique citations were obtained. These 54 were screened by title and abstract. This selection procedure resulted in 14 relevant articles. Further evaluation of the full text eliminated 6 more articles because they were not relevant to the subject of the systematic review. Finally, 8 articles meeting the inclusion criteria were obtained for data extraction and analysis.

Study Characteristics:

All the studies were clinical studies that had been conducted in India, Spain, France, Philadelphia, New York, and China. A University or Dental Hospital was the setting in all the studies. A total of 68 participants were investigated based on the different types of mandibular defects. The study included both genders. The participants had a clinical diagnosis of oral squamous cell carcinoma, ameloblastoma, gun-shot injuries, and OKC. Mean age –10 to 50 years of age, tumors being the main causative factor. There was a considerable methodological heterogenicity between the studies, in the parameters assessed and the outcomes evaluated. The eight studies were included in patients having large mandibular defects. A total of 68 patients were evaluated as follows: Bone quality, functional outcome, and esthetics.

Table I: Summary Of Patient Demographics

STUDY ID	AUTHOR	YEAR	COUNTRY	SETTING	MEAN AGE	NO OF PARTICIPANTS
1	Alberto Rocha Pereira et al	2017	Philadelphia	University Hospital	39 years	2
2	Balaji SM	2016	India	Balaji Dental and Craniofacial Hospital	41.5 years	9
3	Lorena pingarron-martin et al	2014	Spain	University Hospital	39.5 years	8

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4	N. Zwetyenga et al	2012	France	University De Bourgogne	43.5 years	14
5	R.S Neelakandan et al	2011	India	Meenakshi Ammal Dental College and Hospital	not mentioned	20
6	Madan Nanjappa et al	2011	India	VS Dental College and Hospital	30 years	4
7	J. Chen et al	2010	China	University Hospital	30 years	7
8	M. Abraham Kuriakose et al	2003	New York	New York university School of Medicine	45 years	4

Overview Of Study Characteristics:

Alberto Rocha et al in 2017 evaluated a total of 2 patients which showed good functional outcome, acceptable esthetics and bone showed good consolidation. A follow up of 5 years was done. The author concluded that this technique serves to establish bone transport as a valuable alternative to bone-free flaps in the reconstruction of large segmental mandibular defects. The authors conducted this study on a very limited number of participants, that could have been increased to yield a definitive result on statistical grounds and establish that TDO as a better alternative to free flap.

Balaji S.M in the year 2016 evaluated a total of 9 patients with a duration of 8.6 years and he concluded that esthetics obtained after surgery was acceptable and bone formed was of good quality, however, he did not mention anything about the functional outcome. Although they concluded that TDO is potentially beneficial for patients with segmental bony defects.

Lorena Pinagarron-Martin et al in 2014 evaluated 8 patients and concluded that in these cases, two corresponded to gun-shot injured patients who needed additional 15mm bone grafting, one patient who required body mandibular reconstruction with a 15mm free iliac crest graft, and finally 3 patients presenting body and symphyseal mandibular defects, whose integral reconstruction was made necessary with an additional 18mm bone graft. The Symmetrical facial balance was achieved in all cases.

N. Zwetyenga et al in the year 2012 evaluated 14 patients with a follow up of 77 months and concluded that transport distraction osteogenesis allow total or partial restoration of oral function, provides an acceptable esthetics, functional outcome and the amount of bone formed was also satisfactory which enables the patient to resume a reasonable quality of life.

R.S. Neelakandan et al in the year 2011 conducted a study on a total of 20 patients where he mentioned the acceptable functional outcome and the good esthetics, however, they did not mention anything about the bone formation and duration of follow up. Madan Nanjappa et al in the year 2011 concluded that rehabilitation of the patient resulted in acceptable functional esthetics and bone formation, but the number of participants included in the study could have been increased to yield a definitive result on statistical grounds, however, authors concluded that TDO is a reliable and affordable treatment option. J.

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Chen et al in the year 2010 concluded that TDO provides satisfactory functional outcomes, acceptable esthetics, and excellent bone formation. M. Abraham Kuriakose et al in the year 2003 conducted a study on 4 patients with the critical segmental mandibular defect and they concluded that mandibular reconstruction with distraction osteogenesis is a potentially useful technique; however,esthetics and duration of follow up were not mentioned in the study.

Table Ii: Summary Of Study Characteristic And Parameters Of Included Study

AUTHOR	STUDY DESIGN	TYPES OF DEFECTS	PARAMETERS ASSESSED		
			FUNCTIONAL OUTCOME	ESTHETICS	BONE QUALITY
Alberto Rocha Pereira et al	Clinical Study	Oral squamous cell carcinoma	Satisfactory	Acceptable	Good consolidation
Balaji SM	Clinical Study	Ameloblastoma, Odontogenic keratocyst, Mucoepidermoid carcinoma,	Not Specified Acceptable	Acceptable	Good quality
Lorena pingarron-martin et al	Clinical Study	Ameloblastoma, Gun-shot injury	Satisfactory Acceptable	Acceptable	Additional bone grafting needed
N. Zwetyenga et al	Prospective Study	Gunshot injury	Acceptable	Acceptable	Sufficient bone was obtained
R.S Neelakandan et al	Clinical Study	Maxillo-Mandibular Defects	Satisfactory	Acceptable	Not specified
Madan Nanjappa et al	Prospective Study	Ameloblastoma, Reconstruction plate fracture complex odontoma, follicular ameloblastoma	Satisfactory rehabilitation	Not Mentioned	Acceptable
J. Chen et al	Prospective Study	Ossifying fibroma, Ameloblastoma, OKC	Satisfactory	Good	Excellent
M. Abraham Kuriakose et al	Clinical Study	Critical Segmental Defect	Acceptable	Not Mentioned	Bone grafting needed

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Table Iii: Summary Of Duration Of Follow Up And Conclusion Of Included Study

STUDY ID	AUTHOR	DURATION OF FOLLOW UP	CONCLUSION OF THE STUDY
1	Alberto Rocha Pereira et al	5 Years	This technique serves to establish bone transport as a valuable alternative to bone free flaps in the reconstruction of large segmental mandibular defects.
2	Balaji SM	8.6 Years	TDO potentially benefits patients with segmental bony defects following tumour ablation in mandible. It is an unanswering tool to achieve sufficient bone in the mandible in patients who cannot undergo aggressive surgery or poor general health.
3	Lorena pingarron- martin et al	Not Mentioned	Patients' education and awareness about the proper use of the transport-disc distraction device is important to optimise functional outcomes.
4	N. Zwetyenga et al	77 Months	Osteogenic Distraction with bone transport allows total or partial restoration of oral function, provides an acceptable appearance, and enables patients to resume a reasonable quality of life.
5	R.S Neelakandan et al	Not Mentioned	The future of bone transport relies on innovations that would accelerate mineralization of new bone regenerate and biomechanical developments in the device design, like automated miniature transport device for better patient compliance.
6	Madan Nanjappa et al	Not Mentioned	Transport distraction osteogenesis using indigenous distractors is a reliable yet affordable option for reconstruction of mandibular defects.
7	J. Chen et al	27 months	TDDO is now an option for reconstruction of segmental mandibular defects. It is difficult for a single-step TDDO to reconstruct a mandibular defect involving body, angle, and the whole ramus.
8	M. Abraham Kuriakose et al	Not Mentioned	Mandibular reconstruction with distraction osteogenesis is a potentially useful technique in selected patients with segmental mandibular continuity defects after ablative head and neck cancer surgery.

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TDO- Transport Distraction Osteogenesis. TDDO- Transport Disc Distraction Osteogenesis.

Discussion:

This systematic review of the available literature was conducted to identify evidence of reconstruction of mandibular defects using transport distraction osteogenesis. All 8 studies included reported on postoperative outcomes after transport distraction osteogenesis. The chief goal that can be achieved by Transport distraction osteogenesis is best described by Sacco and Chepeha as to restore bony continuity using in situ bone to create an anatomically correct regenerate that is better than bone grafting or revascularized free-tissue transfer.

It is well documented in orthopaedic literature that Transport distraction osteogenesis is a reliable method for simultaneous treatment of composite bone and soft tissue defects, which also is one of the most important indications of Transport distraction osteogenesis. It remains a question to the TDO experimentation and research, as to what the ideal length of the defect that can be reconstructed with this modality[1]. Alberto Rocha Pereira et al in the year 2017 presented a new technique for reconstruction of large curvilinear mandibular defects with distraction osteogenesis and early open callus manipulation. In this study, they had described 2 clinical cases treated according to this technique, one with a 6-cm mandibular defect where a sagittal plane manipulation was performed, and the other with a 7-cm defect and axial plane manipulation.[19] Five years post-surgery, both patients had achieved full stable reconstruction without the need for bone grafting, and obtained good facial symmetry, with no recorded complications.

Balaji SM in the year 2016 studied a group that consisted of 9 cases of TDO for the reconstruction of the segmental defect following tumor resection, of which 5 cases were of benign and 4 cases were of malignant transformation tumor resection. The mean bony defect length was 48mm. The mean distracted bone lengthening was 43mm, with a mean consolidation period of 17.9 weeks. The bony defect involved the Hemi-mandibular angle in 4 patients, Hemi-mandibular body in 3 patients, with greater involvement of the body, symphysis in 2 patients, and of the bilateral mandibular body in two patients. Except for 2 patients who required additional bone grafting to complete union with the residual bone, the other 7 patients in the distraction zone showed the complete ossification by radiological evaluation. The mean consolidation period of 13.56 weeks ranging from 12-15 weeks with the mean follow-up years is about 8.7 years for the cases. Out of the 9 cases, one case had a recurrence in the follow-up period and underwent resection with reconstruction using a reconstruction plate in the created bone. The overall success rate of TDO was 88.9% despite adequate case selection and TDO protocol. A study included 8 patients with a mean age of

39.5 years. The authors concluded that TDO is an alternative to conventional and more invasive procedures when we face severe segmental mandibular defects reconstruction. It shows the potential to restore better anatomical bone regeneration, also providing soft tissues and reducing donor-site morbidity. Patients' education and awareness about the proper use of the transport-disc-distraction device is important to optimize functional outcomes.4

N. Zwetyenga et al in the year 2012, conducted a study that showed that reconstruction of large bone and soft-tissue defects of the inferior third of the face is possible using various surgical techniques. Patients who require these procedures need to be in good general health may have sequelae linked to donor sites, and required several interventions to achieve good aesthetic and functional results. The aim of this study was to report outcomes in patients with large mandibular and soft-tissue defects treated using osteogenic distraction with bone transport.[10] Between 2001 and 2008, 14 patients had undergone distraction with bone transport. Most patients were men (92.1%).[10] The mean age was 43.1 years. The average mandibular bone reconstruction was 13.6cm. The mean duration of distraction was 2-3 months.[10]No infection occurred, and in all cases, reconstruction of soft tissues was obtained. Two patients had non-union and underwent reconstruction using an iliac bone graft.[10]Patients with enough bone height (57.1%) had dental implants. 44 implants were inserted, two of which were lost.10 36 implants were activated. Six patients had satisfactory oral rehabilitation with an implant-supported prosthesis. A study on a total of 4 participants with the mean age of 30 years. The authors concluded that the bone

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regenerate was clinically as hard as the adjacent unaffected mandible and radiologic evidence of bone regeneration was observed. R. S. Neelakandan et al in the year 2011 conducted a study on a total of 20 patients. The authors concluded that TDO was a promising modality of reconstruction of maxillo-mandibular defects with excellent clinical results, it has the disadvantage of prolonged duration of treatment, follow up, and the use of bulky transport devices. The future of bone transport relies on innovations that would accelerate mineralization of new bone regenerate and biomechanical developments in the device design, may it be an automated miniature transport device for better patient compliance. Improvisation in techniques involved in controlling the vectors during the TDO remains critical, as the technique usually is utilized to reconstruct long span defects of the bone.1 A study in 2010 concluded that two-step distraction osteogenesis treatment was beneficial in all patients. The distraction length ranged from 43 to 55mm horizontally and from 35 to 42mm vertically.[20] The treatment period lasted for 14-48 months, longer than expected. It was mainly caused by the patient's failure to return for a visit in time. A consolidation period of 16 weeks was enough, judged by the high-degree ossification on the radiograph and the intra-operative view of the new bone. All patients demonstrated satisfactory mouth opening through exercise, with a maximum incisal opening from 31 to 42mm. Although various authors have reported reconstruction of large defects, Zhang and Zhang have described 3-12cm defects to be optimal for considering TDO. Currently, TDO for facial skeleton finds its application for segmental defects of the mandible, neo- condyle regeneration, distraction for calvarial defects, achieving alveolar height for prosthesis, and even for the maxillary alveolar defects. Segmental defects may be a result of ablative surgery for odontogenic tumors, surgical removal of cancers, chronic bone infections, blast injuries, gunshot wounds.[1]M. Abraham Kuriakose et al in the year 2003 conducted a study on 4 patients with the critical segmental mandibular defect and they concluded that mandibular reconstruction with distraction osteogenesis is a potentially useful technique, however, esthetics and duration of follow up were not mentioned in the study. Parameters assessed by all the authors varied and hence a standardization for comparison could not be done. In a study conducted in 2016, the functional outcome was not specified. Two studies conducted by Lorena Pingarron Martin and Madan Nanjappa et al in 2011 and in 2014 did not mention about the duration of the following was not mentioned. In two studies conducted by Madan Nanjappa et al, in 2014 and M. Abraham Kuriakose et al, in 2016 the authors did not specify the esthetics of the patient, however, they concluded that TDO is a useful and affordable treatment option for the reconstruction of segmental mandibular defects. 4 out of 8 studies assessed in this systematic review concluded that TDO could be used as a standard treatment protocol for mandibular defects which ameliorates the need for grafting. The remaining 4 studies did not mention the parameters that could have been used the sample size and a longer duration of a follow. TDO studies could be conducted in a randomized controlled setting on cases such as TMJ-ankylosis, condylar agenesis/ congenital abnormalities of the condyle with a standardized patient population, a better control setting and set parameters for evaluation with a longer duration of follow up.

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