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COMPARATIVE EVALUATION OF TRADITIONAL ENDODONTIC ACCESS AND MINIMALLY INVASIVE ACCESS CAVITY IN TERMS OF RELATIVE FRACTURE STRENGTH IN ENDODONTICALLY TREATED MANDIBULAR MOLARS - A SYSTEMATIC REVIEW OF IN-VITRO STUDIES.

Endodontics

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ABSTRACT

Objective: This systematic review was executed with the aim of evaluating whether minimally invasive access preparations increase the fracture strength of endodontically treated mandibular molars in comparison to traditional endodontic access cavity preparations. **Methodology:** A comprehensive search of electronic databases namely, Google scholar, Web of Science, Scopus, Cochrane Library, Wiley Online Library, PubMed, Science Direct and relevant online registers was carried out, using appropriate MeSH terms and text words. PICOs criteria was decided prior to the article selection process. The identification and screening process was coherent with PRISMA statement and suitable full text reports were finalised for the study. Additionally, the quality and risk of bias of selected studies were also assessed. **Results:** A total of 633 articles were procured from online mediums. After the screening process, six studies in accordance with inclusion criteria were finalised for this review. Discrepancies were noted in the sample size, fracture resistance test methodologies and fracture strength values of finalised studies. Out of 6, a single study was deemed as having moderate risk of bias and the rest, low risk of bias. **Conclusion:** Improvement in fracture strength of endodontically treated mandibular molars with conservative access approach was not evident. Ideally, this assessment should be made via randomized clinical trials against the reference intervention.

KEYWORDS

Traditional endodontic access, Conservative access cavities, Fracture strength, Mandibular molars, Minimally invasive.

INTRODUCTION:

Viability of an endodontically treated tooth depends on a cluster of factors, noteworthy of them being, its stress bearing potential, complete elimination of necrotic material and effective irrigation. All of the above factors are heavily influenced by access preparation and design. An adequate access opening will provide ease to the operator in terms of visibility and accessibility of the root canal orifices. In recent times, attention has also been brought to the importance of preserving dentin to promote longevity of the tooth by enhancing its biomechanical response to masticatory forces.[1]Therefore, it becomes essential that we achieve clarity in terms of the type of access design that best pertains to the case presented to us and secondly, whether retaining as much natural tooth structure as possible will in fact increase fracture strength of the treated tooth.

Preparation of traditional endodontic access cavities (TEC) entail removal of all carious structure, complete de-roofing of the pulp chamber and *extension for prevention* which refers to removal of dentin obstructions to establish clear access to root canal orifices.[1] Conventional access cavity preparation technique has been adopted by dental practitioners since time immemorial as it offers several advantages, few of them being, straight line access to apical segment or primary curvature of the canal, location of inconspicuous canal orifices, potential for copious irrigation and most importantly, operator convenience in instrumentation. On the contrary, authors such as Gluskin and C.Peters believe that with the advent of enhanced illumination in dentistry, magnification and availability of highly flexible endodontic instruments, this approach may be deemed overly invasive as probability of the tooth for structural fatigue is increased.[2]

More than a decade ago, David Clark and John Khademi revolutionised the key considerations for long-term preservation of endodontically treated teeth, stating that directed dentin and enamel conservation reinforced an endodontically treated molar and no man-made material or technique could compensate for dentin lost in the pericervical region.[3] Additionally, they advocated for the necessity of a modified access design to reduce or eliminate fracture potential.[3]

Minimally invasive dentistry (MID) as stated by J.Gutmann, involves application of the philosophy *'a systematic respect for original tissue'* in dental practices.[4] Minimally invasive endodontics (MIE) refers to minimalistic removal of dentin during all three phases of root canal treatment : a) coronal access preparation, b) radicular apical preparation and c) flaring of the canal that connects the coronal preparation to the apical.[5]Numerous access cavity designs have been proposed that conceptually adhere to MID. Contracted, truss, ninja, and computer assisted access cavities are examples of conservative and ultraconservative access preparations that are employed in MIE.[6] The following systematic review evaluates the impact of minimally invasive access cavities over traditional endodontic access cavities on fracture strength of lower molars.

METHODOLOGY:

An elaborate systematically strategized search through relevant online databases and registers was carried out by an independent reviewer, using appropriate MeSH terms and text words as mentioned in table (I). Inclusion and exclusion criteria for reports that were to be reviewed or discarded were based on PICOs guide decided prior to the selection process, as highlighted in figure (a). The identification and screening process was coherent with PRISMA statement and suitable full text reports were accordingly finalised for the study, as depicted in figure (b). Information and data extracted from these reports include year of publication, journal of submission, author(s), title, methodology, results and conclusion, as presented in table (iii). Table (iv) shows quality and risk of bias assessment of individual studies, done using a method adapted by previous reviewers, E.Silva [7] and Saeed [8]. Parameters reported in individual studies were assigned a tick mark symbol (√) while those unreported, a cross symbol (×). Studies were categorized as having a low risk of bias if five or more parameters were reported out of six, moderate if three or four were reported and high if less than 3 were reported.

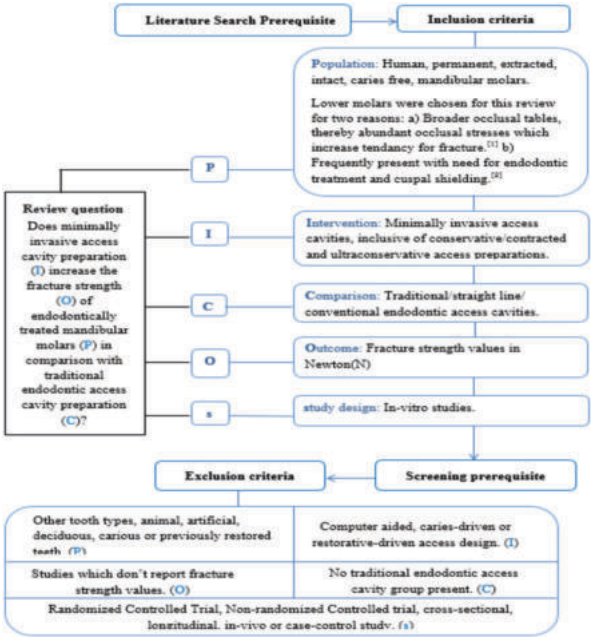

Fig (a): Flow Diagram Depicting PICOs Criteria For Study Inclusion And Exclusion.

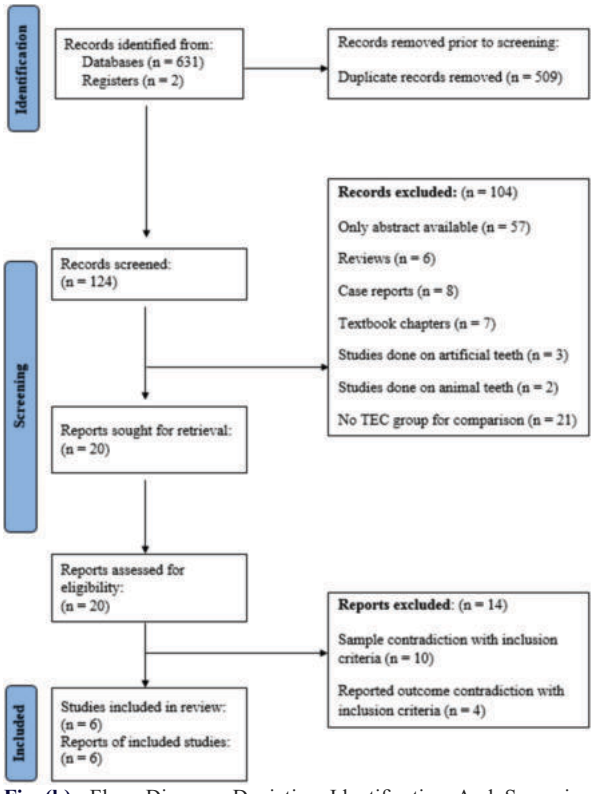

Fig (b): Flow Diagram Depicting Identification And Screening Process For This Review As Adhering With PRISMA Statement.[10]

Table (I): Records Identified Via Online Databases And Registers.

Medium	Medical Subject Heading Terms (MeSH) and Text Words (TW)	Title	Number of records (a)	Total
Databases	'Minimally invasive Endodontics' 'Access cavities' 'Minimally invasive access cavities' 'Stress' 'Fatigue' 'Structural failure'	Google scholar Web of Science Scopus Cochrane Library Wiley Online Library PubMed ScienceDirect	a = 157 a = 82 a = 122 a = 74 a = 14 a = 113 a = 69	n = 631
Registers	'Biomechanical response' 'Traditional endodontic access cavities' 'Contracted endodontic cavities' 'Conservative endodontic access cavities' 'Fracture resistance' 'Fracture strength'	PROSPERO Open Science Framework Cochrane Library of Systematic Reviews	a = 1 a = 0 a = 1	n = 2

Table (ii): Excluded Full Text Reports (n = 14) With Respective Reasons.

Authors	Reason for exclusion
Brent Moore et al. [11] Gabiana Rodrigues Freitas et al. [12] Mohammad Sabeti et al. [13] Gabriela Rover et al. [14]	Tooth type: Maxillary molars.
Hasna et al. [15] Sarvaiya UP et al. [16]	Tooth type: Maxillary central incisors.
Chlup Z. et al. [17]	Tooth type: Maxillary and mandibular premolars.
Gianluca Plotino et al. [18]	Irrelevant tooth types also included in study along with mandibular molars.
Rajesh Krishan et al. [19]	Irrelevant tooth types also included in study along with mandibular molars.
Mohamed Saber et al. [20]	Von Mises (VM) stresses were recorded as opposed to fracture strength values.
Yujie Fu et al. [21]	Mean maximum stress in cervical region recorded as opposed to fracture strength values.
Chris S. Ivanoff et al. [22]	Tooth type: Mandibular premolars.
Keyong Yuan et al. [23]	Stress concentration areas assessed as opposed to fracture strength values.
Mahmoud Y. Abou et al. [24]	Fracture strength improvement assessed in lower molars between truss access cavity preparations and artificial truss restorations.

Table (iii): Synopsis And Salient Elements Of Included Studies (n=6) In Descending Chronological Order

1	*Journal of publication, year*	*Review title – Authors*		
Australian Endodontic Journal 2021		Influence of access cavity design on fracture strength of endodontically treated lower molars - *Aline Maske et al. [25]*		
Methodology		***Results***	***Conclusion***	***Main outcome***
Sample size	Fifty human lower third molars with standard crown dimensions.		The type of access cavity preparation did not influence the fracture strength of endodontically treated lower molars.	Minimally invasive access cavity preparation did not improve fracture strength of endodontically treated lower molars.
Groups assigned (n=10/ group)	***Description***	***Fracture Strength*** Mean ± SD* (N)		
S	Positive control (healthy tooth).	3722 ± 829.5		
ET	Negative control (conventional endodontic access CEA and no restoration).	1233 ± 325.1		
NI	Negative control (minimally invasive endodontic access MEA and no restoration).	1425 ± 222		
ETR	CEA + restoration with Bulkfill flow.	1994 ± 551.9		
NIR	MEA + restoration with Bulkfill flow.	2526 ± 704.5		

		The S group showed greater mean fracture strength, differing statistically from the ET, NI, ETR and NIR groups.		

2	**Journal of publication, year**	**Review title – Authors**		
International Endodontic Journal 2020		The influence of endodontic access cavity design on the efficacy of canal instrumentation, microbial reduction, root canal filling and fracture resistance in mandibular molars - *Barbosa, A. F. A., et al. [26]*		
Methodology		**Results**	**Conclusion**	**Main outcome**
Sample size	Thirty extracted intact mandibular molars matched based on similar anatomical features.		Conservative access cavity preparation did not offer any benefit in comparison to traditional endodontic cavity preparation in terms of fracture strength.	Minimally invasive access cavity didn't improve fracture strength of endodontically treated lower molars.
Groups assigned (n=10/group)	**Description**	**Fracture strength** Mean ± SD (N)		
TEC	Traditional endodontic access cavity.	748 ± 238		
CEC	Contracted endodontic access cavity.	971 ± 377		
TAC	Truss access endodontic cavity.	1033 ± 414		
	Statistically insignificant differences were found among the groups (P<0.05).			

3	**Journal of publication, year**	**Review title – Authors**		
International Endodontic Journal 2020		A laboratory study of the impact of ultraconservative access cavities and minimal root canal tapers on the ability to shape canals in extracted mandibular molars and their fracture resistance. - *Augusto CM et al. [27]*		
Methodology		**Results**	**Conclusion**	**Main outcome**
Sample Size	Thirty-two intact extracted mandibular molars.		Ultraconservative endodontic cavities did not offer any advantages in comparison to the traditional endodontic cavities on the fracture strength of mandibular molars.	Minimally invasive access cavity did not improve fracture strength in endodontically treated lower molars.
Groups and subgroups assigned (n=8/ group)	**Description**	**Fracture strength** Mean ± SD (N)		
TEC .03	Traditional endodontic access cavity and 0.03 taper preparation.	1103 ± 369		
TEC .05	Traditional endodontic access cavity and 0.05 taper preparation.	1393 ± 165		
UEC .03	Ultraconservative endodontic access cavity and 0.03 taper preparation.	1289 ± 446		
UEC .05	Ultraconservative endodontic access cavity and 0.05 taper preparation.	1357 ± 328		
		Statistically insignificant differences were observed in fracture resistance in any of the tested groups (P > 0.05).		

4	**Journal of publication, year**	**Review title – Authors**		
Journal of Endodontics 2018		Influence of access cavity preparation and remaining tooth substance on fracture strength of endodontically treated teeth - *Giacomo Corsentino et al. [28]*		
Methodology		**Results**	**Conclusion**	**Main outcome**
Sample size	Hundred extracted human mandibular first and second molars.		TRECs do not increase the fracture strength of endodontically treated teeth in comparison with CECs and TECs.	Minimally invasive access cavity did not improve fracture strength.
Groups assigned (n = 10/ group)	**Description**	**Fracture strength** Mean ± SD (N)		
Control	Intact teeth	1791.6 ± 114.6		
TEC	Traditional Endodontic Access Cavity	1149.8 ± 288.4		
CEC	Conservative Endodontic Access Cavity	1380.5 ± 259.2		
TrEC	Truss Endodontic Access Cavity	1237.1 ± 411.4		
TEC + 3	Traditional Endodontic Access Cavity with 3 residual walls (mesial wall removed).	1082.5 ± 231.3		
CEC + 3	Conservative Endodontic Access Cavity with 3 residual walls.	1292.1 ± 197.6		
TrEC + 3	Truss Endodontic Access Cavity with 3 residual walls.	1024.2 ± 227.9		
TEC + 2	Traditional Endodontic Access Cavity with 2 residual walls (mesial and distal wall removed).	618.4 ± 185.2		
CEC + 2	Conservative Endodontic Access Cavity with 2 residual walls.	654.6 ± 97.5		

TrEC + 2	Truss Endodontic Access Cavity with 2 residual walls.	741.8 ± 223.5		
		No significant differences were found between the 3 tested access cavities (P > 0.05). Significant differences were observed between the different number of residual walls (P < 0.05).		

5	**Journal of publication, year**	**Review title – Authors**		
Journal of Endodontics 2018		The effects of endodontic access cavity preparation design on the fracture strength of endodontically treated teeth: traditional versus conservative preparation. - *Özyürek T, Ülker Ö, Demiryürek EÖ, Yılmaz F. [29]*		
Methodology		**Results**	**Conclusion**	**Main outcome**
Sample size	Hundred extracted mandibular first molar teeth.		CEC preparation did not increase the fracture strength of teeth with class II cavities compared with TEC preparation.	Minimally invasive access cavity did not improve fracture strength.
Groups assigned (n = 20 /group)	**Description**	**Fracture Strength** Mean ± SD (N)		
Control	Intact teeth	2472.63 ± 308.21		
TEC + EverX Posterior	Traditional endodontic cavity preparation and restoration with EverX Posterior as base material and composite resin.	971.03 ± 114.28		
CEC + EverX Posterior	Conservative endodontic cavity preparation and restoration with EverX Posterior as base material and composite resin.	1008.25 ± 216.83		
TEC + SDR	Traditional endodontic cavity preparation and restoration with SDR as base material and composite resin.	1451.92 ± 205.39		
CEC + SDR	Conservative endodontic cavity preparation and restoration with SDR as base material and composite resin.	1674.07 ± 238.36		
		There was no statistically significant difference in the endodontic access cavities prepared used the TEC and CEC methods and restored using the same composite base material (P > 0.05).		

6	**Journal of publication, year**	**Review title – Authors**		
Journal of Conservative Dentistry, 2018		Evaluation of remaining dentin thickness and fracture resistance of conventional and conservative access and biomechanical preparation in molars using cone-beam computed tomography: An in vitro study - *Deep Makati et al. [30]*		
Methodology		**Results**	**Conclusion**	**Main outcome**
Sample size	Sixty extracted intact mandibular molars.		Conservative group has double the fracture resistance of conventional group.	Minimally invasive access cavity preparation increased the fracture strength of endodontically treated lower molars.
Groups assigned (n=30/ group)	**Description**	**Mean load at fracture** Mean ± SD (N)		
TEC	Traditional endodontic cavity	1546.69 ± 199.88		
CEC	Conservative endodontic cavity	3208.76 ± 281.69		
	Conservative group showed comparatively higher fracture resistance with a mean difference of 1662.07 N.			

*SD - Standard deviation.

Table (iv): Quality And Risk Of Bias Assessment Of Individual Studies.

	Study					
Parameters	*Aline Maske et al. [24]*	*Barbosa, A. F. A. et al. [25]*	*Augusto CM et al. [26]*	*Giacomo Corsentino et al. [28]*	*Özyürek T, Ülker Ö, Demiryürek EÖ, Yılmaz F. [29]*	*Makati D et al. [30]*
Sample size calculation	✓	✓	✓	χ	✓	χ
Sample with similar dimensions	✓	✓	✓	✓	✓	χ
Control group (intact teeth)	✓	✓	χ	✓	✓	χ
Whether obturation performed?	✓	✓	✓	✓	✓	✓
Whether restoration performed?	✓	✓	✓	✓	✓	✓

Statistical analysis carried out	✓	✓	✓	✓	✓	✓
Risk of bias	Low	Low	Low	Low	Low	Moderate

RESULTS:

A total of 633 articles were procured from online mediums. Number of individual articles obtained from each database and register have been mentioned in table (I). PRISMA flowchart outlined in figure (b) presents details of the screening process via which 6 studies in accordance with inclusion criteria were finalised for this review. Reasons for exclusion of 14 full text reports have been stated in table (ii).

All 6 studies analysed lower molars, some authors having experimented with first molars [29], third molars [25], both first and second molars [28] and lastly, ambiguity with regards to the same in remaining studies [26, 27, 30]. Sample sizes were majorly non-uniform, ranging from 30 [26] to 100 [28, 29].

Irregularity was also observed in the fracture resistance test methodologies:

1) **Crosshead speed**: 0.5 mm/min [25, 28], 1 mm/min [29, 30] and unreported [26, 27].

2) **Load diameter**: 2 mm [28], 4 mm [26, 27], 6 mm [29], 7.5 mm [25] and unreported [30].

3) **Region of load application:**

[25] - Inclined planes of the occlusal contacts in the intercuspal position in the mesiodistal direction.

[26, 27] - Central fossa.

[28] - Central fossa at a 30˚angle from the long axis of the tooth.

[29] - Central fossa in the lingual direction at a 15˚angle to the longitudinal axis of the teeth.

[30] - Unreported.

The fracture strength values showed extreme variability ranging from 748 ± 238 N [26] to 1994 ± 551.9 N [25] for TEC and 1033 ± 414 N [26] to 3208.76 ± 281.69 N [30] for MEA. Refer table (iii).

Table (iii) depicts respective author's inferences from fracture strength values of individual studies in the 'results' column. All authors have reported a statistically insignificant difference in the fracture strength values of TEC versus MEA except for Makati D. who has reported a mean difference of 1662.07 N.

According to the parameters that were considered for quality and risk of bias assessment of individual studies, out of 6, a single study [30] was deemed as having moderate risk of bias and the rest, low risk of bias as shown in table (iv).

DISCUSSION:

Dentin is a multilevel composite that acts like a semi-rigid pipe ideally, the analogy being symbolic of its buttressing potential.[3] It has been established that dentin in an endodontically treated tooth has approximately the same durability of that in a vital tooth.[3] Isufi et al. estimated the percentage of volume of dentin and enamel removed (DER) in maxillary, mandibular premolars and molars after access cavity preparation, by utilising CBCT and micro-CT imaging in specimens with various access designs. It was reported that DER in TEC, CEC and Ultraconservative Endodontic Cavity (UEC) groups was more than 15%, less than 15%, and less than 6% respectively, with a statistically significant difference among all groups in all tooth types that were analysed ($P < 0.05$), confirming that minimally invasive endodontic cavities (MIEC) particularly UEC category result in substantially lesser loss of coronal tooth structure. [31] Therefore, if lesser volume of dentin is removed during conservative and ultraconservative access preparations, fracture strength of the tooth should be amplified but findings of this review revealed quite the opposite.

In five [25 – 29] out of 6 studies that were conducted on lower molars, the conclusion arrived upon was that TECs and CECs have roughly similar values of fracture strength. These studies were found to have a low risk of bias, although, discrepancies were found in fracture resistance test methodologies, wherein 2 studies [26, 27], centric force was applied and in 3 studies [25, 28, 29], eccentric force was applied, these inconsistencies account for variability in the fracture strength values reported as teeth are prone to structural failure under lesser load with application of eccentric forces in contrast to axial forces.[18]

Merely Makati D. et al. [30] found a statistically significant difference between fracture strength values of TEC and CEC, thereby verifying that CECs present with an overall improved fracture strength in comparison to TECs. However, this study presented with a moderate risk of bias as sample size wasn't calculated, the teeth did not have similar dimensions for standardization and there was a lack of a control group. Furthermore, uniformity in fracture resistance test methodology with other studies could not be assessed as cross head diameter and specific region of load application on sample surface were unreported.

In a separate study, Gianluca Plotino et al. [18] reported that the mean load at fracture for lower molars in the TEC group was significantly lower than the intact, CEC, and NEC groups ($P < 0.05$). The choice for UEC was Ninja Endodontic Cavity (NEC), whereas in the studies included in this review, the popular choice has been Truss Access endodontic Cavity (TAC).

Ninja access or point access, is prepared through the central fossa and progressed apically with minimal lateral extension. Through this little hole, all the canals are accessed. With regards to truss access or orifice-directed dentin conservation access, mesial and distal access cavities targeting the canal orifices are prepared, and the dentinal bridge between both cavities is maintained in mandibular molars.[6] The verdict of this study seems to align with a study by Rajesh Krishan et al. [19] that was carried out on mandibular first molars, maxillary incisors and mandibular second premolars, wherein it was found that fracture strength for CEC was significantly higher ($P < 0.05$) than for TEC with mean load at fracture reported as 1586.9 ± 196.8 N for molars in CEC group. However, the fracture resistance tests were performed without obturation and restoration of sample teeth. Mahmoud Y. Abou et al. [24] conducted a study on mandibular first molars exclusively and in doing so, found insignificant differences between fracture strength values of TEC and TAC groups ($P > 0.05$).

Compromise in rigidity of root foundation of endodontically treated teeth is caused by loss of pulp chamber roof to some extent.[32] Dentin roof strut and/or dentinal bridge act as reinforcing structural bracing systems.[1] The finalised studies comprising this review were scrutinized to check for these features as well since these are essential components of MIEC. Excluding the study by Maske at al., it was found that soffit was maintained in all CEC groups.

The reliability of these studies should be evaluated by the level of information provided, that would affirm direct implication of MEA in clinical practice, this must be dictated by apt simulation of clinical scenarios. Periodontal ligament was simulated by coating the root surface of sample molars with molten wax or light body putty impression material in 4 studies [26, 27, 29, 30]. Bone was simulated by mounting the teeth in self-curing acrylic. Thermocycling of the samples simulates thermal changes that occur in the oral cavity, it was carried out in 2 studies [25, 30]. Regardless, in vitro studies can't completely simulate the clinical oral condition and challenges faced in a clinical setting such as extent of decay, oral hygiene status, patient cooperation, mouth opening, patient age and systemic issues etc. On that account, there is a need of randomized clinical trials against the reference intervention on the subject, which will produce distinctly practical evidence.

CONCLUSION:

In the context of this systematic review, the effectiveness of a minimally invasive access cavity in terms of improved fracture strength of endodontically treated lower molars in comparison to a traditional access preparation, isn't explicitly evident by the data and information available, hence it should not be advocated as being favourable to the conventional approach. Ideally, this assessment should be made via randomized clinical trials against the reference intervention.

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