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Digital complete denture versus conventional complete denture. A systematic review

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ABSTRACT

Computer engineered complete dentures (CECDs) or digital dentures have been increasingly being fabricated by dentists these days. Enhanced clinical outcomes are only one of the many benefits of computer-aided design and computer-aided manufacturing (CAD-CAM) technology's introduction to clinical and dental laboratory procedures.

The objective of this systematic review was to compare and summarise the findings of clinical research pertaining to CD manufacture in terms of the distinctions between CAD-CAM technology and traditional approaches.

Medline/PubMed, Cochrane Library, SciELO, Web of Science, and Embase were the databases searched for this systematic review was conducted in accordance with the criteria established by the Cochrane Collaboration and in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA 2020 guidelines. Based on the results of this systematic review, conclusions were drawn and presented.

Keywords- Digital CD, Cad Cam, Complete denture.

Introduction

Computer engineered complete dentures (CECDs) or digital dentures have been increasingly being fabricated by dentists these days. Enhanced clinical outcomes are only one of the many benefits of computer-aided design and computer-aided manufacturing (CAD-CAM) technology's introduction to clinical and dental laboratory procedures.The concept of computer-aided design and computer-aided manufacturing (CADCAM) CDs first developed in Japan, with first English-language article explaining the CAD-CAM technology for CD fabrication.(1) Prosthetic dentistry has embraced it for few years now where it enables the automated and rapid production of digital castings via scans, planning with appropriate software programmes, the construction of prototypes, and the production of components from diverse materials. Using a digital library to save digital casts and drawings for CAD-CAM complete dentures (CDs) allows for significant clinical time savings. The digital archive might be stored as a regular tessellation language file in a database. Both subtractive and additive approaches of manufacturing (including fast prototyping) are viable options for making the CD (milling of prefabricated blocks). The subtractive method is currently the norm; the polymethylmethacrylate (PMMA) resin for the denture base

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is often injected under high heat and pressure and then machined into a block. When compared to commonly treated PMMA materials, the blocks exhibit superior mechanical and physical properties. On the other hand, traditional materials have a rougher surface, bigger dimensional shifts, more internal bubbles, lower fracture resistance, and fewer residual monomers, all of which might have an effect on dental hygiene. One of the most prevalent problems among CD users is denture stomatitis, which can be brought on by a leaky denture base. Therefore, CDs created using CAD/CAM technology may be preferable to conventional dentures. Clinical studies have been conducted to examine this hypothesis, although these are far from sufficient. Prior to 2015, to the best of our knowledge, no research evaluating the clinical outcomes of CECDs were available, as far as we are aware. Prior to 2015, the majority of reports on CECDs were descriptions of fabrication techniques (1,2,5,6,8,9.) The objective of this systematic review was to compare and summarise the findings of clinical research pertaining to CD manufacture in terms of the distinctions between CAD-CAM technology and traditional approaches.

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MATERIALS AND METHOD

This systematic review was conducted in accordance with the criteria established by the Cochrane Collaboration (Cochrane Handbook for Systematic Reviews of Interventions, Handbook 6.2) and in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA 2020 guidelines for developing and reporting a systematic review.

Study is registered in research center of Riyadh Elm University with IRB number"FRP/2021/436/715/696"

The PICO (population, intervention, comparison, and outcome) framework was used to analyze the studies measuring retention, tissue surface adaptability, time and expenses, and unplanned visits among those getting prosthetic therapy using CDs (outcome). The search strategy and the following inclusion criteria were used to select the studies: Clinical research, comparisons of CAD-CAM and conventional dentures, and English-language investigations utilizing CAD-CAM technology for scanning (intraoral or in a lab), design, printing, or milling CDs. Methodological reviews, case studies, and clinical reports were disregarded.

Medline/PubMed, Cochrane Library, SciELO, Web of Science, and Embase were the databases searched. We ran searches for items published between 2000 and June 2022 with MeSH keywords "Removable Complete Denture", "Complete Denture", "Removable Denture", "CAD-CAM", "Digital".

Also undertaken was a manual search of certain periodicals and relevant research on dental dentures and digital technologies. The article selection and data collection were carried out by two previously calibrated reviewers (SA and NT); publications relevant to the theme were sought out, submitted, and accepted using the kappa test ($k = 1.0$). There were two other researchers who looked through the selected publications, data collection/analysis, and potential for bias. A second expert provided clarification on some of the unknowns and offered technical support. Clinical studies that were included in the meta-analysis were evaluated according to predetermined criteria (randomized controlled trials, cohort studies, cross-sectional studies, or case-control studies). Two researchers (SA and NH) independently extracted all the data in the tables (qualitative data and bias risk) and had their work independently verified by a third researcher. The potential for bias was assessed by classifying studies according to their design and the outcomes they produced in the clinic. Critical Appraisal Skills Programme (CASP) criteria for randomized controlled trials were used to assess the quality of the publications included, and a narrative synthesis method was used to analyze and present the results.

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Table 1: *Risk of bias assessment with the recommended approach of Cochrane ROB 2*

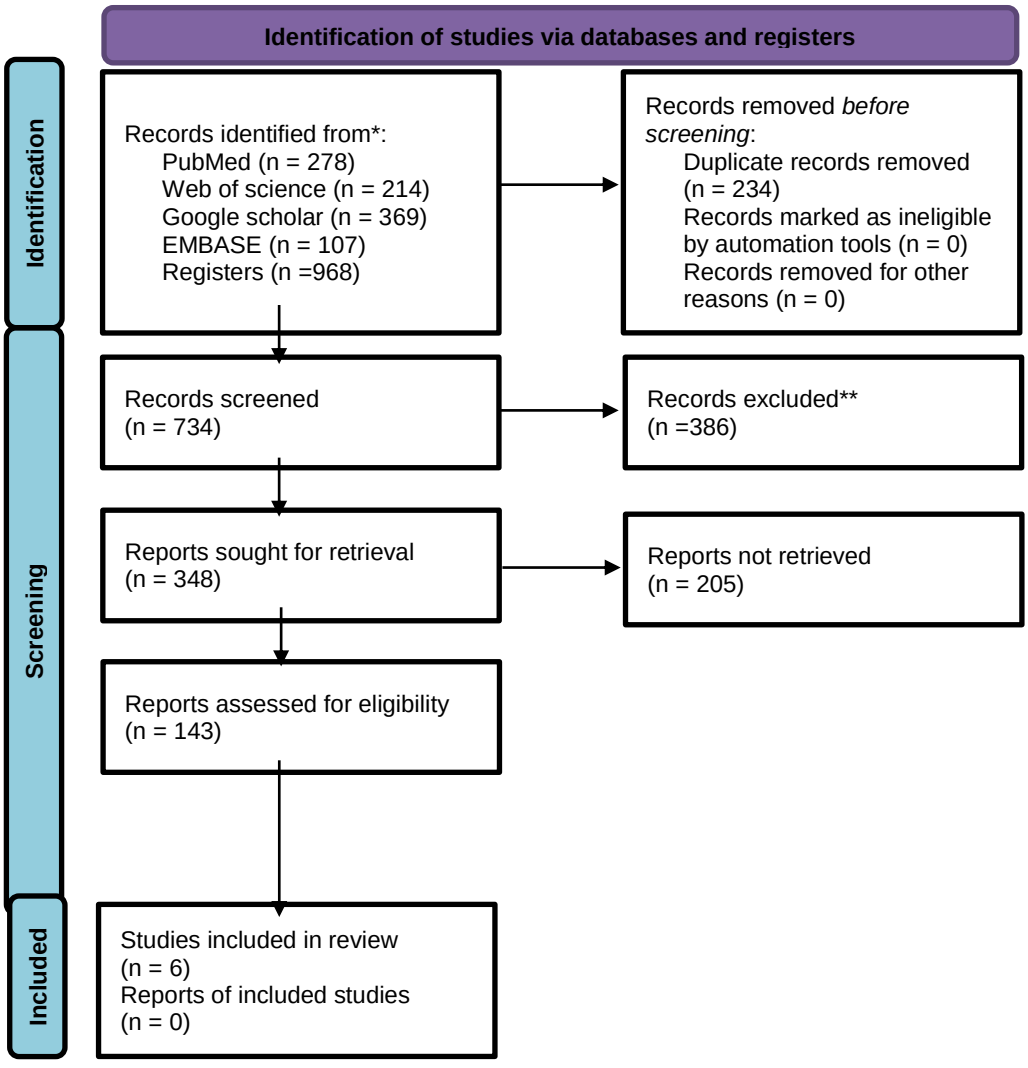
Authors	D1	D2	D3	D4	D5	Overall
Ohara et al (2022)	+	+	+	+	?	+
Hafez et al. (2021)	?	+	?	+	?	?
Hwang et al. (2019)	+	+	−	+	+	+
Deng et al (2021)	+	+	+	+	?	+
Wei et al (2020)	?	+	+	+	+	+
Yoon et al. (2020)	+	?	?	+	?	?

RESULTS

The original search yielded 968 titles, of which 348 were chosen based on their title and abstract. Nine articles were discarded as they did not match the inclusion criteria. Criteria examined were retention, time and cost, adaptation of the tissue surface, patient experience and satisfaction, and unplanned and postinsertion adjustment visits of digital and traditional CDs.

The authors of this systematic review followed the steps outlined in the PRISMA 2020 flowchart (shown in Figure 1). Duplicates that were discovered simultaneously across databases were eliminated. Screening articles by their titles and abstract summaries yielded a final count of 143. After reading the entire articles and making connections with the inclusion and exclusion criteria, additional articles were removed. This systematic review included 6 articles, all of which were evaluated for potential bias.

Fig 1-PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



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DISCUSSION

Several CD-manufacturing methods were recorded, from the more traditional pack and press and injection molding to the more modern milling and digital light processing. The key findings were separated depending on the goals, with a summary of each chosen research. Two papers examined the retention of traditional versus digital dentures. Twenty participants (n = 20) in each study were randomly assigned to receive either a physical CD or a digital CD in the maxilla. In their initial experiment, Yoon et al. (2013) discovered that full digital dentures created applying the milling process offered greater retention than regular CDs. Subsequently, the study team investigated the influence of using adhesives (Fixodent; Procter & Gamble Co) (Fixodent; Procter & Gamble Co) (7). In terms of retention, Hwang et al discovered that digital CDs topped regular CDs. When adhesives were employed, there were no statistically significant variations in the retention averages of digital CDs (58.79 N) and conventional CDs (52.08 N) (P=.088). In addition, the use of the adhesive did not substantially increase the preservation of standard CDs (P=.570).

Two papers contrasted the time necessary to create digital and traditional dentures; the Avadent block was employed in both cases to fabricate digital CDs. According to research by Kattadiyil et al., creating a CD the old-fashioned way took significantly (P =.003) more clinical time than creating one digitally, with an average difference of 205 minutes. Similarly, Srinivasan et al. (2017) showed statistically significant differences in the methodologies (P =.02, P =.002), with mean discrepancies of 108 minutes for a single-arch CD and 233 minutes for opposing CDs, with digitally created CDs needing less time. (8) In addition, Srinivasan and colleagues evaluated fluctuations in material pricing and showed that there were large (P.001) differences between techniques. It was shown that when comparing laboratory expenses across methods, digital CDs were the most cost-effective option (P =.008). Comparing the surface adaptation of different digital techniques (digital light processing and milling) with the conventional approach (pack and press) in 9 edentulous persons with 12 fully edentulous arches was the subject of one article (7 maxillary and 5 mandibular) (7 maxillary and 5 mandibular). It was determined through this study that there were no statistically significant differences (P>.05) between the three approaches of making denture bases in terms of absolute tissue surface adaptation. Maxillary dentures created with DLP technology adapted better to tissues in the stress zones of the maxillary arch (residual ridge and midpalatal suture) compared to conventionally constructed dentures (P .001, P .000). The milling method generated a maxillary denture with minimum gaps between the supporting tissue and the denture base. Both digital methods showed more accurate adaptation in the lingual inclination region of the mandibular denture compared to the conventional denture. Using a questionnaire and a 5-point Likert scale, one article assessed the experience and satisfaction of 16 persons who were rehabilitated using CDs manufactured using conventional and digital processes (0 to 4). (0 to 4). Based on the data collected, it was determined that there is a statistically significant (P .001) gap between the ratings for analog CDs and digital CDs, with digital CDs being the clear winner. An open anterior occlusal connection on one of the digital CDs necessitates a remake of the mandibular CD. A decrease in retention, stability, and occlusion necessitated relining of one CD produced using the normal process. (9)

One article was chosen to assess the frequency of unplanned post-insertion adjustment visits for CD patients. This research included 106 nonsmoking individuals, the majority of whom were female. The first 33 were given CDs produced using the normal method (injection moulding), while the remaining 73 were given digital dentures (milling). There was no statistically significant difference (P >.05) in the frequency of unplanned postinsertion changes for participants given digital vs traditional CDs. (10)

The qualitative synthesis findings reveal that CDs generated using CAD-CAM technology have stronger retention than CDs manufactured using traditional methods. (11) Other criteria, including experience, contentment, length, and cost, revealed yet considerable variances. In terms of retention, both experiments demonstrated superior retention in CAD-CAM CDs compared to conventional CDs, perhaps due to a better match with the prepolymerized CAD-CAM CDs. Denture adhesives, contrary to previous research, were

shown to significantly reduce the preservation of CAD-CAM CD. The glue may not be able to settle properly because the milled CDs are more adapted to, and in closer touch with, the maxillary tissues. The effectiveness of denture adhesives on CADCAM dentures needs to be investigated further. A good treatment needs an intimate adaptation of the intaglio surfaces of dentures, which directly effects the retention and longevity of CDs. Yoon et al. reported a substantial difference between milled and DLP-manufactured CDs, with the latter enabling improved adaptation to the tissues of the maxillary ridge and hard palate. Additionally, DLP-manufactured dentures may lead to greater adaptability in stress-bearing areas compared to traditional and CAD-CAM-milled dentures. (12) In addition, CDs generated using the conventional technique showed a propensity to push the centre of the palate, as contrast to CDs manufactured with the DLP and milling procedures in two studies. This finding was comparable with that of Hwang et al who observed an improvement in trueness and surface adaptability in CDs created using the DLP and demonstrating a mismatch within 100 mm. CAD-CAM-milled CDs offer higher versatility, as indicated by earlier studies. These gains may be related to the more exact standardisation of processes utilizing CAD-CAM systems and the lower polymerization shrinkage, a crucial factor with older approaches. One of the key benefits of the CAD-CAM technology is the lowering of chairside time, with treatment finished in two to three sessions, depending on the system and protocol implemented. CAD-CAM CDs needed an average of 205 minutes less chairside time than conventional dentures, according to Kattadiyil et al. 108.3 minutes for maxillary CDs and 233 minutes for maxillary and mandibular CDs. Other research has also indicated that the CADCAM method for CDs is feasible. (13) Consequently, the flexibility of this process, with the capacity to obtain definitive impressions, interocclusal relationship records, and tooth selection at the first session, is the major aspect impacting these outcomes. In contrast, the conventional strategy involves five to six appointments, which could be troublesome for therapists with less skill. The cost of therapy must also be assessed, since it impacts the application and acceptance of the treatment among physicians and patients. Srinivasan et al analyzed the expenses associated with treatments for traditional and CAD-CAM-milled CDs by splitting them into clinical fees, clinical supplies, and laboratory costs, as well as a labour cost per hour. They determined that, with the exception of clinical supplies, therapy utilizing CAD-CAM CDs was substantially less expensive than other criteria and that a cheaper treatment alternative was available in general. This research was done in Switzerland, and the authors acknowledged that it was difficult to generalize these findings to other countries owing to changes in pricing systems, which was a drawback of the study. Kattadiyil et al revealed much larger preferences for CAD-CAM CDs in terms of patient comfort, mastication, prosthesis selection, and technique efficiency as compared to conventional CDs. However, various faults have been detected; one of the CAD-CAM CDs needs replacement owing to an open anterior occlusal connection. The retention, stability, and occlusion of a CD produced using the usual procedure were compromised, needing relining. It is possible that issues encountered by patients throughout therapy contributed to these findings. Patients' attitudes toward treatment may have changed because fewer visits and fewer procedures are necessary thanks to the CAD-CAM workflow. There was no correlation between the technique of CD insertion and the number of unplanned post-insertion adjustment visits required, but rather, the number of patients with a single CD and the number of patients who attended scheduled appointments after CD insertion. This may be associated to the regularity of treatment regimens or the location of the clinical practices, which may be far and difficult for patients to visit, according to the research. This view is backed by the fact that just lower percentage of patients attended planned visits. For CAD-CAM, the average number of unscheduled visits was 1.7%, whereas for regular CDs, it was 1.8%. In contrast, Bidra et al. found 3.3% unscheduled visits on an changes on average after implantation. (14) However, the small sample size and 2-visit technique that included conventional CDs and implant-supported overdentures in this experiment raise concerns that these findings may not generalize to the general population. In future studies, uniform techniques for assessing postinsertion visits should be established. This systematic review was restricted by the tiny number of clinical studies published on this issue that satisfied the inclusion criteria and the potential of publications written in languages other than English. Lack of randomization of participants, difficulty in calculating sample size, and the inability to conduct blind evaluations of patients and study staff were all

problems. However, there was concern regarding the elimination of several clinical abnormalities that may impact treatment outcomes, such as palatal tori, alveolar ridges with considerable undercuts, and reduced salivary flow. Researchers in a few studies classified participants according to the shape of their maxillary arches and/or palatal throats. (15,16,17) In addition, inadequate sample numbers and methodological inconsistencies hindered meta-analysis. (18,19,20) Therefore, it's important for future studies to find ways to standardize treatment plans so they provide the same clinical outcomes. The association between denture adaption and retention and the function of denture adhesives in CADCAM CDs should be explored in subsequent study. To analyze variations between operations, prolonged follow-up durations are needed in clinical research. CDs can be made using any method at this time, but there will be financial and clinical repercussions.

Table 2. Summary of selected articles.

Authors	Title	Research Design/year	Research Purpose	Methodology	Result	Conclusion
Ohara et al (21)	Patient satisfaction with conventional dentures vs. digital dentures fabricated using 3D-printing: A randomized crossover trial	Randomized trial (2022)	study aimed to evaluate patient satisfaction with conventional dentures (CDs) and DDs fabricated using 3D printing.	The primary outcome was patient satisfaction, quantified using a 100-mm visual analog scale, which assessed chewing efficiency, pain, stability, retention, comfort, esthetics, ease of cleaning, phonetics, and general satisfaction. Secondary outcomes were quality of life (QOL), number of visits, time required for definitive denture fabrication, number of adjustment appointments, and time required for denture stabilization after denture delivery.	**:** Patient satisfaction with CDs was superior in terms of phonetics, ease of cleaning, stability, comfort, and general satisfaction. Secondary outcomes such as social disability and the number of clinic visits were significantly lower in patients with DDs. However, the two groups showed no significant differences in the other outcomes.	Although patient satisfaction or QOL with DDs may be somewhat inferior to that with CDs, 20% of patients preferred and used DDs daily. Thus, DDs fabricated using 3D printing may have comparable practicality and efficacy to CDs.
Abdelrahim et al. (22)	Assessmentof hardness flexural modula=us and bond strength of acrylic denture bases fabricated by 3D digital method	In vitro (2021)	Study aimed to evaluate and compare the effect of the processing technique on the hardness, flexural modulus, and bond strength of the different denture base resins.	Three processing techniques were used in the present study to fabricate the tested samples; compression-molded fabrication method “control group”, and two different three-dimensional (3D) fabrication methods (CAD/CAM milled “subtractive”, and 3D printed “additive”). .	`CAD/CAM milled samples showed statistically significant higher hardness and flexural modulus values followed by the conventional compression molded, and 3D printed respectively. While the results of shear bond strength showed no statistically significant difference among the three different processing methods.	Processing technology has a significant effect on the hardness and flexural modulus of the material. While there is no effect to the fabrication technique on the teeth bond strength.

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Hwang et al. (23)	Assessment of the trueness and tissue surface adaptation of CAD-CAM maxillary denture bases manufactured using digital light processing	Case control (2019)	To investigate whether specific stress-factors correlate with Sleep bruxism (SB) activity.	A total of 20 denture bases (10 per technique) were also fabricated on the duplicated master casts using DLP and MIL. Ten denture bases were additionally made using PAP.	. The DLP denture base showed the best denture base fifit among the 3 techniques with a small interquartile range.	DLP maxillary denture base showed better trueness and tissue surface adaptation of 100 mm of the 3-dimensional surface deviation than the MIL and PAP denture bases
Deng et al. (24)	Evaluation of functional suitable digital complete denture system based on 3D printing technology	Case control (2021)	a digital complete denture restoration workflow (Functional Suitable Digital Complete Denture System, FSD) was proposed and preliminary clinical evaluation was done.	Forty edentulous patients were enrolled A redesigned complete denture was printed as a mold to fabricate final denture that was delivered at the third visit. To evaluate accuracy of impression made by diagnostic denture, the final denture was used as a tray to make impression, and 3D comparison was used to analyze their difference. To evaluate the clinical effect of FSD, visual analogue scores (VAS) were determined by both dentists and patients	there was no statistical difference between the two groups	FSD can simplify the complete denture restoration process and reduce the number of visits. The accuracy of impressions made by diagnostic dentures was acceptable in clinic. The VASs of both dentists and patients were satisfied.

Wei et al (25)	**Evaluation of** clinical efficacy of a kind of digital complete denture	Clinical trial (2020)	To compare the clinical efficacy of a kind of complete dentures fabricated using computer aided design/computer aided manufacturing (CAD/CAM) workflow with that of the complete denture fabricated using conventional workflow.	Twenty edentulous patients were included in this prospective, single-blind, self-controlled clinical trial. Two pairs of complete dentures were fabricated for each participant: one using the functional suitable denture (FSD) system with CAD/CAM, and the other using conventional fabrication workflow.	The VAS scores of the twenty patients in FSD denture group on general satisfaction, ease of cleaning, ability to speak, esthetics, stability, and oral health status on these six domains were higher than that of conventional denture group 3 months after delivery.	The clinical efficacy of the FSD complete denture is comparable to that of the conventional complete denture. As for patient satisfaction and oral health related quality of life, FSD dentures received comparable scores as conventional complete dentures did.
Yoon et al. (26)	Tissue surface adaptation of CAD-CAM maxillary and mandibular complete denture bases manufactured by digital light processing: A clinical study	Clinical study (2020)	Purpose of this clinical study was to assess the tissue surface adaptation of complete denture bases generated by the DLP technique and to compare the adaptation with that of denture bases manufactured by 5-axis milling (MIL) and pack-and-press (PAP) method.	9 participants with 12 edentulous arches (7 maxillary and 5 mandibular) were included in this study. For each edentulous arch, the complete denture bases with occlusion rims were prepared by 3 different techniques (PAP, MIL, and DLP).	No statistically significant differences were found among the 3-denture base fabrication techniques with respect to the ATA values of either arch (P>.05). The DLP base exhibited a higher frequency of negative RTA values than the MIL base.	The DLP denture base was likely to exhibit intimate tissue adaptation in the stress-bearing areas of maxillary arches compared with the PAP denture base. The maxillary MIL denture base was likely to exhibit small gaps between the supporting tissue and denture base. Both DLP and MIL mandibular denture bases were likely to show intimate adaptation on the lingual slope compared with the PAP base.

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CONCLUSION

Based on the results of this systematic review, conclusions were drawn. Rehabilitation using dentures created digitally provides more retention than CDs made using traditional approaches. Digital dentures required less clinical time and were less expensive overall than traditional CDs. CAD-CAM CDs exhibited more adaptability than traditional CDs, hence enhancing the patient experience and satisfaction. In terms of the frequency of unplanned post-insertion visits, there were no differences between digital and traditional CDs.A significant reduction in the number of appointments and clinical time, enhanced retention, and digital realizability were the primary benefits cited in a few the reviewed clinical studies. Before definitive conclusions may be established, long-term clinical trials on CECDs are still necessary.

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