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**Review Article**

# The shortened dental arch revisited: from evidence to recommendations by the use of the GRADE approach

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SUMMARY **Clinicians must frequently decide whether or not to treat patients with loss of posterior teeth, a condition called the shortened dental arch (SDA). Although many studies have been reported, there are no clear recommendations for the management of SDA cases. In this work, therefore, an innovative system, the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach, was used to grade the evidence and strength of recommendations for clinical intervention. An extensive literature search for longitudinal studies was conducted on 17 November 2010 in the PubMed and LILACS electronic databases using the term *shortened dental arch*. A 'snowballing' strategy, for example, manual searching of the reference lists of included papers, was also conducted. Unpublished and published studies were sought in ClinicalTrials.gov and in the search engine 'Google' (Scholar) in English, French, German, Italian, Portuguese and Spanish. Finally, grey literature was searched in OpenSIGLE (System for Information on Grey Literature in Europe). Titles and abstracts of 133 articles were initially assessed. Nine studies were finally included. Although there was no difference between the effectiveness of restorative and non-restorative approaches for SDA, fixed partial dentures seem better than removable prostheses. The overall body of evidence was, however, graded as low quality. Two different clinical scenarios are used to illustrate recommendations in the management of SDA cases by the use of the GRADE system. The GRADE approach may improve transparency in a shared decision-making process, mainly under conditions in which the quality of evidence is low or unclear.**

KEYWORDS: **shortened dental arch, quality of evidence, strength of recommendations, quality of life, occlusion, temporomandibular disorders**

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## Introduction

The shortened dental arch (SDA) condition, i.e. occlusion without one or more posterior teeth, has been extensively researched, and several treatment strategies are believed to be acceptable (1–6).

Although many reviews have been published on the SDA concept (7–11), most of these lack a systematic methodological approach (for example, research question, literature search keywords, inclusion/exclusion criteria), so the results obtained might be biased (12). Most studies included in these reviews have cross-sectional designs, which make it difficult to determine causal relationships between SDA and potential problems such as temporomandibular disorders (TMD) or the effectiveness of therapy (e.g. removable partial dentures, RPD) for SDA. Currently, furthermore, there is no clear methodology for using the evidence of studies on SDA in clinical practice. Rational recommendations on this issue would be very helpful for clinicians, who frequently need to manage patients with loss of posterior teeth.

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach is a systematic and explicit means of making transparent judgements in the decision-making process (13–15). The GRADE system clearly differentiates the quality of evidence and the strength of recommendations and



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takes into account factors other than evidence to suggest therapeutic approaches (13). The system has been supported and used by several organisations (http://www.gradeworkinggroup.org) and is continually being developed and improved.

The objectives of this study were therefore threefold: (i) to systematically assess outcomes from non-treatment and treatment approaches for SDA cases in longitudinal studies; (ii) to assess whether or not there are differences between the effectiveness of restorative approaches for SDA; and (iii) to assess the quality of retrieved evidence and the strength of recommendations by the use of the GRADE system, with the objective of generating recommendations for the clinician.

## Materials and methods

*PICO approach*

The Population, Intervention, Comparator, Outcome (PICO) approach (16, 17) was used to frame two research questions:
P: adult patients
I: prosthetic restorations
C: no treatment
O: quality of life, masticatory function, aesthetics; TMD, occlusal problems, tooth loss:

1. 'Are there any quantitative and qualitative differences between restorative and non-restorative approaches for SDA in adult patients?'
2. 'Are there any quantitative and qualitative differences between different restorative approaches for SDA in adult patients?'

*Literature search*

On 17 November 2010, an extensive literature search was conducted in the PubMed and LILACS (Latin American and Caribbean Health Science Information) electronic databases using the term *shortened dental arch*. The 'snowballing' strategy (18), for example, manual searching of the reference lists of included papers, was also conducted to retrieve potential studies. Unpublished and published studies were sought by the use of ClinicalTrials.gov and the Internet search engine 'Google' (Scholar) in English, French, German, Italian, Portuguese and Spanish. The keyword *shortened dental arch* was used to retrieve articles published in the language of the original search engine (for example, articles in Italian in Google Italy, articles in German in Google Germany, etc.). Finally, grey literature was searched in OpenSIGLE (System for Information on Grey Literature in Europe; http://opensigle.inist.fr/).

*Measures of outcome*

Qualitative (quality of life, masticatory function and aesthetics) and quantitative (temporomandibular problems, occlusal problems and tooth loss) measures of outcome were used.

*Inclusion and exclusion criteria*

Longitudinal studies (randomised controlled trials, RCT, and controlled trials, CT) were included in the study. Cross-sectional and survey studies were excluded. Other types of study, for example, case reports, reviews and studies dealing with measures of outcome not reported here, were also excluded.

*The GRADE system: from evidence to recommendations*

The GRADE system (13–15) was used to assess the quality of the available evidence and the strength of recommendations for approaches dealing with SDA cases. This system assesses the whole body of evidence, and results from RCT are initially ranked as high-quality evidence (14). Our confidence in the quality of the whole body of evidence can, however, be reduced when other factors are considered in the judgement. In the same way, results from studies with weaker designs, for example, CT, can be upgraded to a higher level of evidence when other variables are taken into account (Fig. 1).

The second component of the GRADE system is the determination of the strength of recommendations, i.e. the extent to which we can be confident that the desired effects of intervention outweigh the undesired effects (15). The strength of recommendations is dichotomised as weak or strong in the GRADE system. The quality of evidence is only one of the variables to be assessed when judging whether a recommendation is weak or strong (Table 1).

*Rationale of the assessment*

Evidence retrieved from the literature search was summarised on the basis of study design, and its quality

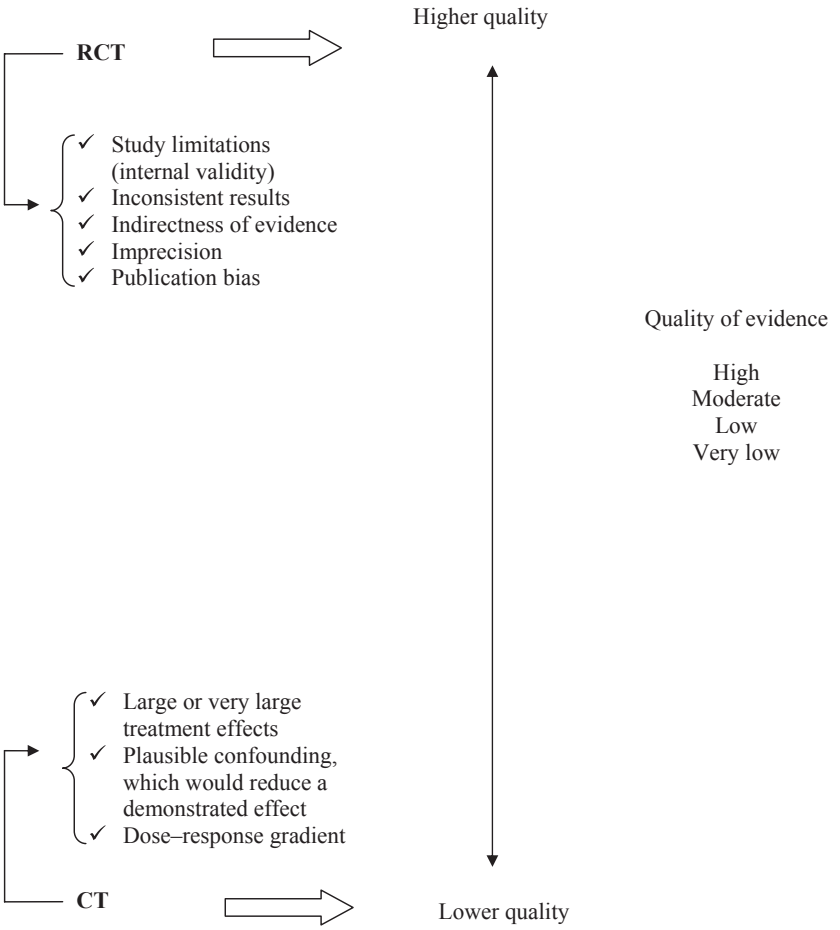



**Fig. 1.** Grading of Recommendations Assessment, Development and Evaluation approach for assessment of the body of evidence on shortened dental arch.

**Table 1.** Determination of the strength of recommendations by the use of the GRADE system

| Strength of recommendation | Factors determining the strength | Rationale |
|---|---|---|
| Definition: The extent to which one can be confident that adherence to the recommendation will do more good than harm. It is categorised as strong or weak | Quality of evidence<br>Uncertainty of the balance between treatment effects and side-effects<br>Uncertainty of the values and preferences of the patients receiving the therapy<br>Uncertainty of the cost-effectiveness of therapy | The key factor differentiating strong from weak recommendations is uncertainty about the advantages and disadvantages when comparing vari ables. The more the uncertainty, the more the likelihood that a weak recommendation is warranted |

GRADE, Grading of Recommendations Assessment, Development and Evaluation.

was upgraded or downgraded depending on the strengths and weaknesses of the studies. The quality of evidence was also assessed by taking into account other variables, for example, the inconsistency, indirectness and imprecision of the evidence (14) (Fig. 1). In the second stage of the assessment, the quality of the evidence was considered together with three other factors, the uncertainty of the balance between treatment effects and side-effects, the values and preferences of the patients receiving the therapy, and the cost-effectiveness of therapy, to determine the strength of the recommendation. The rationale is

explained in Table 1. Different clinical scenarios served as a basis for deciding whether to make a weak or a strong recommendation.

## Results

*Selection of studies*

One hundred and thirty-three studies were initially screened in PubMed. Nine longitudinal studies were finally selected for quality assessment. The detailed literature search process and the reasons for exclusion of studies are reported in Fig. 2.

*Types of study and comparisons*

Four studies were RCT (19–22), and five studies were CT (23–27). More than 10 different endpoints were used to assess the effectiveness of therapy and/or other approaches for SDA. Three studies (23, 24, 27) compared RPD (removable partial denture) with completely dentate (CD) and SDA with CD; two studies (19, 20) compared RPD with SDA and fixed partial denture (FPD) with RPD; two studies (25, 26) compared SDA with CD only; and two studies (21, 22) compared FPD with RPD only (Table 2).

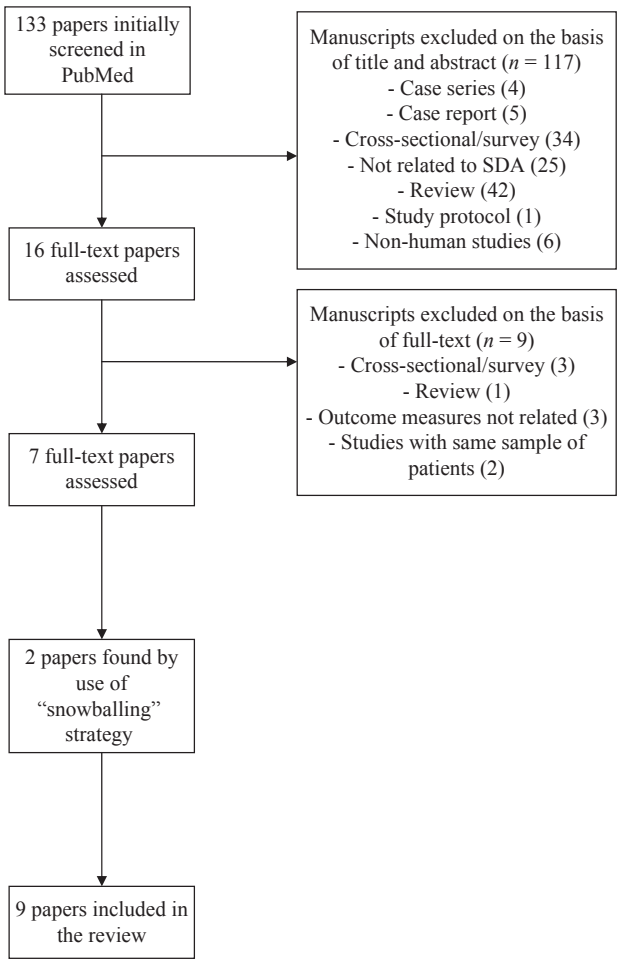



**Fig. 2.** Flowchart of manuscripts screened by the review process.

*Research questions*

For question (1), there was no significant difference between the two approaches, i.e. restorative and non-restorative. For question (2), two studies (21, 22) demonstrated that treatment of SDA with FPD might have benefits for patients compared with RPD treatment. Patients were more satisfied with FPD treatment (21) and had less long-term TMD (22).

*Determining the quality of evidence*

Results from RCT studies were initially categorised as high-quality evidence. On the basis of four other variables (risk of bias, inconsistency, indirectness and imprecision), the quality of the evidence was downgraded (Table 3). The results from the five CT were not upgraded to a higher level, however, because features that could strengthen them, for example 'large magnitude of effect', were not present.

*Recommendations*

The quality of retrieved studies was assessed using the other three components to grade the recommendations (Table 1). Two different clinical scenarios were created to enable the comparison of these variables for the assessment of whether a recommendation should be weak or strong (Fig. 3). In the first scenario, the patient has no concerns regarding possible aesthetic limitations of the 'non-active' therapy for SDA. Treatment costs may also be important in the shared decision process. In this case, the non-treatment approach is more cost-effective than active therapy. Hence, for these reasons, the non-treatment approach for SDA is considered a strong recommendation. In the second scenario, the non-treatment approach is considered a weak recommendation. Furthermore, a patient with high aesthetic demand and no economic restrictions may consider active intervention with both

**Table 2.** Characteristics of the studies selected

| Study | Design | Participants | Intervention (s) | Comparison | Outcome | Results |
|---|---|---|---|---|---|---|
| Creugers *et al.* (23)* | CT | 99 patients with different combinations of missing teeth (premolars and molars) | RPD, RPD (previous), SDA | CD | Awareness of bruxism, occlusal wear score, TMD dysfunction, vertical and horizontal overlap | No significant difference |
| Walter *et al.* (19)† | RCT | 215 patients with complete loss of molars in one jaw | RPD | SDA or (1PM + 2PMFPD)‡ | Tooth loss | No significant difference |
| Aras *et al.* (24) | CT | Forty participants with bilateral missing molars in the mandible | RPD, SDA | CD | Masticatory performance, maximum occlusal force, and occlusal contact area | SDA with lower contact area and occlusal force than CD and RPD groups |
| Witter *et al.* (25)* | CT | 146 patients with different combinations of missing teeth (premolars and molars) | SDA | CD | Pain in TMJ or adjacent regions, Noises/clicking, and restricted mandibular mobility | No significant difference |
| Wolfart *et al.* (20)† | RCT | 34 patients with all molars missing and the presence of at least both canines and one premolar in each quadrant | RPD | SDA or (1PM + 2PMFPD)‡ | OHQoL (OHIP-49), RDC | No significant difference |
| Jepson *et al.* (21) | RCT | Sixty subjects with mandibular SDA | FPD | RPD | Patient satisfaction assessed by the use of questionnaires | More patient satisfaction for the RPD group only |
| Witter *et al.* (26)* | CT | 148 patients with different combinations of missing teeth (premolars and molars) | SDA | CD | Occlusal stability (interdental spacing, occlusal contacts of anterior teeth in intercuspal position, overbite, occlusal tooth wear, and alveolar bone support) | More interdental space in PM area for more anterior teeth in occlusal contact for SDA, lower alveolar bone scores for SDA |
| Witter *et al.* (27)* | CT | 107 patients with different combinations of missing teeth (premolars and molars) | SDA, RPD | CD | Craniomandibular dysfunction and oral comfort | No significant difference |
| Budtz-Jørgensen and Isidor (22) | RCT | 53 patients with mandibular SDA | FPD | RPD | Modified Helkimo's dysfunction index | More TMD for RPD group |

RCT, randomised controlled trial; FPD, fixed partial denture; RPD, removable partial denture; SDA, shortened dental arch; CD, complete dentition; CT, controlled trial; TMD, temporomandibular disorder; OHQoL, oral health quality of life; OHIP, oral health impact profile; RDC, research diagnostic criteria; PM, premolar.

*†Patients derived from same cohort, but studies with different measures of outcome.

‡Some cases where the second premolar (PM) was replaced by a cantilever FPD.

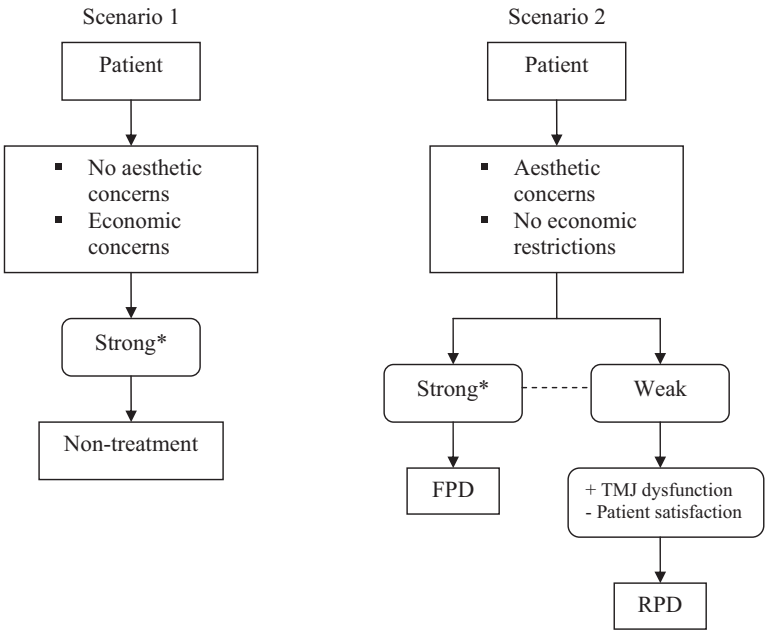
weak and strong recommendations. This happens because the quality of the evidence might generate a 'weaker' recommendation for the RPD approach compared with FPD treatment. This rationale is based on the assumption that FPD might be more effective than RPD treatment (Fig. 3).

**Table 3.** Quality assessment of the overall body of evidence using the GRADE approach

| | Quality assessment | | | |
|---|---|---|---|---|
| Limitations | Inconsistency | Indirectness | Imprecision | Overall quality* |
| The five CT had no positive factors that could upgrade them to evidence of moderate or high quality. Hence, they were regarded as evidence of low quality. Following the Cochrane approach (http://www.cochrane.org/training/cochrane-handbook), three RCT (20–22) were considered to be at unclear or high risk of bias because some key domains were unclear or not met (for example, no allocation concealment and incomplete outcome data). Moreover, one study (19) was considered not at high risk of bias. Taking all studies into account, the evidence was downgraded one level | Because of large variability among measures of outcome, it was not possible to assess the consistency of treatment effects across the studies. Nevertheless, two studies (24, 26) had consistency in one common outcome (occlusal contact area), although this endpoint is not critical for the decision-making process (surrogate endpoint) | Three types of indirectness were considered: indirect (surrogate) outcomes; indirect (between studies) comparisons; and indirectness related to differences between the patients or intervention (applicability). Most studies of this sample reported true endpoints, and there were many head-to-head comparisons: SDA with CD (23–27); RPD with CD (23, 24, 27); RPD with SDA (19, 20); FPD with RPD (19–22). The population was also homogeneous in all studies. So, significant indirectness was not found in this sample of studies | As a measure of imprecision, four articles described the precision of results by the use of confidence intervals (CI) (19, 24, 27). One paper (26) reported results with standard deviation (SD) and CI. One paper (25) reported standard errors (SE). One (20) reported SD only. One (23) reported SD and SE. Two studies did not report any measure of imprecision (21, 22). When SE and CI were assessed, their values were not wide. Nevertheless, in two studies (21, 22), the assessment was not performed, so overall assessment was not possible | Because of study design limitations, the evidence was downgraded to moderate. Because of the difficulty of properly assessing the inconsistency and imprecision, the overall level of evidence was downgraded one more level and was therefore regarded as low |

CT, controlled trial; RCT, randomised controlled trial; SDA, shortened dental arch; CD, completely dentate; RPD, removable partial denture; GRADE, Grading of Recommendations Assessment, Development and Evaluation.

*Because of the heterogeneity of the measures of outcome, it was not possible to initially grade the quality of evidence for each measure of outcome separately, as the GRADE system recommends to determine the overall quality of evidence across outcomes.




* Means the extent to which we can be confident that the desirable effects of intervention outweigh the undesirable effects; FPD: fixed-partial denture; RPD: removable-partial denture; TMJ: temporomandibular joint; the dotted line means the strength of recommendation when both active therapies are directly compared

**Fig. 3.** Two scenarios in which variables other than the quality of evidence are taken into account to determine the strength of recommendations for non-therapeutic and therapeutic approaches.

## Discussion

The results from longitudinal studies on SDA did not reveal any significant difference between non-therapeutic and therapeutic approaches, at least with regard to the measures of outcome assessed. Nevertheless, although two studies (21, 22) demonstrated some advantages of the FPD approach in comparison with RPD, the quality of the evidence was graded as low.

This study informs the reader about an innovative system for grading the quality of evidence and the strength of recommendations. The purpose of the GRADE approach is to close the gap between evidence and clinical practice. The system assesses the evidence taking into account not only the study design but also detailed scrutiny of potential limitations of the whole body of evidence on the topic. Factors such as risk of bias, inconsistency of results, indirectness and imprecision of evidence are considered together to determine a final score (Table 3). Furthermore, GRADE clearly differentiates quality of evidence from strength of recommendation. This is the second step of the decision-making process, in which the quality of evidence is incorporated into other variables (see Materials and methods) to enable transparent and correct judgement of the strength of the recommendation. The concept is realistic, because in a 'multivariable' world, decisions on therapy cannot be made solely on the basis of the quality of the evidence.

Although there might be a relationship between the quality of evidence and the strength of a recommendation (29), i.e. the stronger the evidence, the stronger the recommendation, occasionally, a strong recommendation can be made on the basis of low-quality evidence (for example, the body of evidence on SDA). This happens because patients and dentists might have different perceptions of treatment outcomes (30), and this important aspect should be taken into account when considering treatment strategies. Therefore, because of the low quality of the evidence supporting many dental procedures, the GRADE system might be important for grading evidence and recommendations in dentistry (31).

The evidence was initially downgraded to moderate, because the sample of studies did not consist solely of RCT and the RCT had some shortcomings. Furthermore, because it was not possible to fully assess inconsistency and imprecision (because of methodological limitations of the data), the evidence was downgraded one more level and was therefore scored as low. It is important to emphasise that there is some subjectivity when assessing both the quality of evidence

and the strength of recommendations. Some might argue that it is not an easy task to assess the whole body of evidence and upgrade or downgrade it, taking into account many factors. Nevertheless, as was suggested when the concept of evidence-based medicine (a process in which decision-making is based on intuition, clinical experience and examination of evidence from clinical research) was first described in the early 1990s (32), some intuition and subjectivity will be present in the decision-making process. In addition, because dentists become aware of variables involved in the decision-making process, the GRADE concept may help improve transparency and communication between dentist and patient.

Only longitudinal studies were included in this project. It was decided to exclude studies with cross-sectional design because they may not give information on cause–effect relationships. Cross-sectional studies are important in the determination of the prevalence of diseases and for the identification of possible associations (33). Longitudinal studies are normally conducted to confirm results from cross-sectional studies (33).

The decision to conduct an RCT on therapy and non-therapy approaches might raise ethical concerns. Nevertheless, many studies with low-level designs, for example, the cross-sectional and non-randomised longitudinal studies also included in this review, have already demonstrated that a non-therapy approach might be regarded as alternative therapy. Furthermore, the results of this study confirm findings from a recently published systematic review on posterior bounded edentulous space (BES) (17). In this review, the authors concluded that for untreated BES, occlusal changes in the form of mesio-distal movement of teeth adjacent to the BES and overeruption of unopposed teeth were non-existent or limited to 2 mm in most cases. Most evidence, however, was derived from cross-sectional studies and was scored as very low by the authors. Moreover, BES results are in agreement with the results of the studies included (23, 26) in the systematic review, which also revealed that occlusion changes were self-limiting and became stable with time. This body of evidence might therefore support the conducting of a well-designed and robust RCT including the non-therapy approach, with the objective of confirming, or not, previous findings on SDA. Hence, the dental community should discuss further the importance of conducting such a trial.

This study identified more than 10 endpoints in nine trials, and this makes it difficult to compare key factors such as inconsistency, indirectness and imprecision across studies. Many studies also reported true endpoints as measures of outcome (34, 35); because of their heterogeneity, however, it was not possible to properly compare them. In some grading systems, for example, strength of recommendation taxonomy (SORT) (28, 36), true endpoints, i.e. endpoints that can predict a true outcome or are relevant to the patient, are regarded as a requirement for making a strong recommendation. Hence, to facilitate comparison of trials, further research should focus on selected and validated endpoints.

Authors should also make efforts to report findings in such a way that the precision of evidence can be easily assessed. For example, the authors of this sample of studies reported heterogeneous measures of the imprecision of evidence (14). Although it is sometimes possible to indirectly derive standard errors (SE) to obtain confidence intervals (CI), measures of imprecision such as CI should be clearly and directly reported. As CI comprise the range of values within which you can be 95% (usually) confident that the true value is included, misinterpretation of results can be reduced, mainly when trials have insufficient power to detect differences between treatments (37). Furthermore, in addition to CI, another criterion, the optimum information size (OIS), should be used to ensure that precision is adequate. OIS is the threshold at which the total number of patients included in a systematic review or meta-analysis is less than the number of patients included in a single RCT with an adequate sample size, taking into account the main outcome measure as reference (38, 39). The smaller the difference between the number of patients included in a potentially adequate RCT and in a systematic review or meta-analysis on the researched topic, the greater is the probability of rating down for imprecision. Because of the small number of studies included in this systematic review (nine trials with 310 patients) and the large variability of measures of outcome among studies, the minimum OIS number will probably not be achieved. These results might therefore support the decision to downgrade the quality of the evidence to low.

In summary, this paper systematically describes current evidence from longitudinal studies on SDA and identifies methodological aspects to be improved in future research. This methodological improvement

is pivotal for the future assessment of the body of evidence on SDA treatment. Furthermore, an innovative system to assess the quality of the evidence and the strength of recommendations of clinical procedures is reported. As the GRADE system takes into consideration factors other than scientific evidence, more transparent decisions may be made, mainly when the quality of evidence for a particular approach is low.

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## Conflict of interest

The author is a member of the GRADE Working Group.

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