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# A systematic review and meta-analysis of the role of nutrition and its impact on orthodontic treatment/management

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## Abstract

The nutritional needs already increased by adolescent growth, activity, and stress are further exacerbated by the physical, physiological, and psychological stress that orthodontic treatment causes. Hence, the main objective of this systematic review was to analyze the relationship between adequate nutrition and its impact on orthodontic treatment success rates. Using relevant keywords, reference searches, and citation searches, the databases such as PubMed–Medical Literature Analysis and Retrieval System Online, Web of Science, Cochrane, and Scopus were all searched. “Diet,” “Minerals,” “Nutrition,” “Orthodontics,” and “Vitamins” were the search terms used to scour the database. The 10 studies selected for the systematic review and subsequent meta-analysis could not conclusively establish the correlation between proper nutrition and its impact on orthodontic treatment of the patient. There was virtually little connection between patients’ dietary intake and the effectiveness of their orthodontic treatment. Additionally, a direct causal link between the two could not be established legitimately because the majority of the studies reviewed only noted an impact during the early stages of the treatment.

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## Keywords:

Diet, minerals, nutrition, orthodontics, vitamins

## Introduction

The science of food, the nutrients, and other substances within, their action, interaction, and balance in connection to health and diseases, and the processes by which the organism ingests, digests, absorbs, transports, utilizes, and excretes food substances<sup>[1]</sup> are all included in nutrition. The right amount of nourishment consumed determines the person’s optimal growth and development. Any nutritional deficiency causes severe and long-lasting deformity when tissues and organs are still developing.

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Additionally, diet affects the time of sexual development, delaying menarche in cases of starvation and preponing it in cases of obesity.<sup>[2]</sup> Hippocrates stressed the significance of nutrition, saying “There are many additional maladies coming from inadequacy of diet, different from those of repletion, but no less awful”.<sup>[3]</sup> The scope of orthodontic therapy includes everything from addressing craniofacial complex growth and development to moving teeth through the medium of adjacent periodontal tissues. As a result, diet and orthodontic therapy interact strongly. This is so because orthodontic treatment has an impact on food consumption, quality, and consistency, while nutrition impacts

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periodontal condition, oral flora, healing potential, immune response, and growth of the individual.<sup>[4]</sup> The orthodontic treatment causes physical, physiological, and psychological stress, which increases nutritional needs already raised by adolescent growth, activity, and stress.<sup>[4]</sup> The lack of literature on the subject makes clear how neglected diet is, despite its crucial significance in orthodontic therapy.

Nutritional deficits can have a substantial impact on how well the body's endocrine glands work, which can affect both the dentition and the growth and development of the entire body.<sup>[5]</sup> The likelihood of cleft lip and palate in the progeny of animals fed a diet deficient in folic acid, riboflavin, and zinc is increased.<sup>[6]</sup> Malnutrition has been linked to retarded growth and the formation of face bones.<sup>[7,8]</sup> Reduced skull base length, jaw height, maxillomandibular width, and reduced facial height<sup>[8]</sup> are all possible effects of malnutrition. The use of attachments and force elements during orthodontic treatment might have a negative impact on dietary intake and jeopardize the patient's nutrition. However, a balanced diet is necessary for orthodontic treatment to be successful. As a result, it enters a vicious cycle that both the patient and the orthodontist should be aware of. The connection between nutrition and orthodontic therapy is discussed in this essay. Orofacial structure development is also influenced by the method of obtaining nourishment. Breastfeeding is essential for the growth of dentofacial structures and the development and synchronization of the orofacial muscles, which in turn help with the maturation of numerous key functions as a whole.<sup>[9]</sup> In contrast to subjects on a hard diet, subjects on a soft diet had narrow arches caused by underdeveloped muscles and supporting structures.<sup>[10]</sup> The incidence of class II malocclusion increased when coarse and fibrous meals were avoided, according to research.<sup>[11]</sup> Vitamins and minerals are a crucial part of a balanced diet and play a crucial role in promoting healthy development and growth. While vitamin A excess and vitamin D shortage produce skull softening as a result of decreased calcium deposition and also enhance the susceptibility for cleft lip and palate, vitamin A insufficiency and protein deficit result in inadequate bone growth concurrent with malocclusion of teeth.<sup>[5,12]</sup> Calcium and phosphorus metabolism, which is necessary for the development of the skeleton and teeth, is aided by vitamin D.<sup>[12]</sup> Lack of vitamin D results in rickets, maxillary dysplasia, difficulty closing facial sutures, an open bite, transverse hypodimension, and a malformed palate.<sup>[5]</sup>

To prevent appliance breakage and bracket debonding, orthodontists advise their patients to stay away from chewy, sticky, sticky-gummy, or very hard foods.<sup>[13]</sup> Choosing a soft diet over a hard one during orthodontic

treatment causes dietary modifications that enhance fat intake while decreasing fiber and carbohydrate intake. During orthodontic treatment, copper and manganese levels decreased, according to Strause and Saltzmann.<sup>[14]</sup> It was attributed to avoiding nuts, whole grains, and eating fewer fruits and vegetables. Copper is necessary for the synthesis of hemoglobin and red blood cells, as well as for collagen cross-linking, redox system enzymes, and proper pigmentation.<sup>[13,15,16]</sup> Manganese is essential for glucose metabolism and bone remodeling.<sup>[14]</sup>

Hence, our primary objective in conducting this systematic review and meta-analysis was to examine research that had been written about the impact of nutrition and other dietary habits on various orthodontic treatment techniques. Additionally, we looked at whether nutrition played a role in the success or failure of orthodontic therapy.

## Materials and Methods

### Protocol employed

This systematic review was performed as per the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) strategy and rules from the Cochrane group and the book *Orderly Reviews in Health Care: Meta-Examination*.<sup>[17]</sup>

### Review hypotheses

Through this systematic review, our primary objective was to review studies that were published in the orthodontic literature about the effects of nutrition and other dietary patterns on the various orthodontic treatment modalities. Also, we sought to identify if nutrition was critical in the success/failure of orthodontic treatment.

### Study selection

There were a total of 484 documents discovered after an extensive search on online journals, and 231 of the papers were selected initially. Following that, 164 similar/duplicate articles were eliminated, which resultantly made 67 separate papers available at first. The abstracts and titles of submissions were then reviewed, and a further 57 papers were eliminated. Finally, 10 documents that met the requisite inclusion and exclusion criteria were chosen, which primarily included *in vitro* studies, literature reviews, and comparative assessments [Figure 1].

### Inclusion criterion

Articles that contained relevant data for our review objectives were selected for full-text screening. Studies that reported clinical trials, *in vitro* studies, randomized/non-randomized studies, systematic/literature reviews

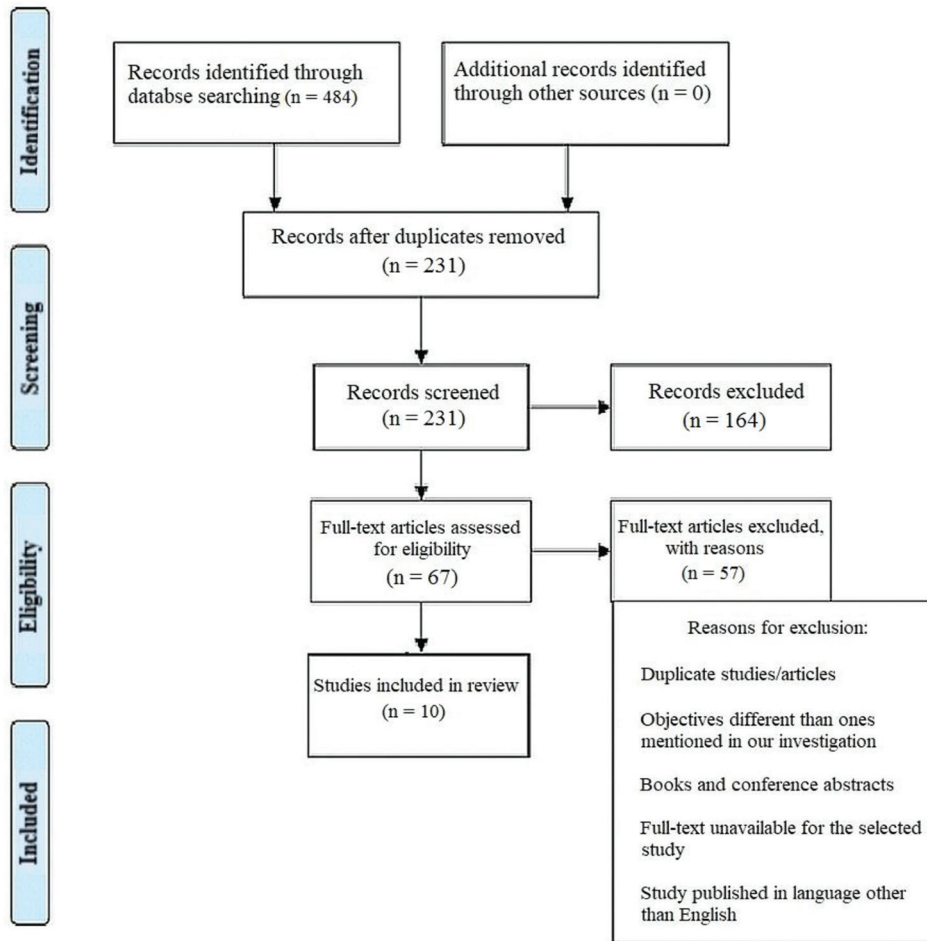


Figure 1: Representation of the selection of articles through PRISMA framework

containing substantial sample volume, and detailed case reports were considered for inclusion in our review [Table 1]. We also monitored studies that possessed higher methodological quality.

### Exclusion criteria

The following were excluded from the scope of our systematic review: incomplete data, seminar presentations, scholarly articles, placebo-controlled studies, and opinion articles.

Since the literature available on this topic was quite scant in volume, we did not limit our search in terms of the time period when the studies were published, that is, we took into account all the papers that were published with context to our topic (where the number of papers itself was found to be quite sparse in number). Also, excluded were literature reviews and cases published in languages other than English.

### Search strategy

The databases such as PubMed–Medical Literature Analysis and Retrieval System Online, Web of Science,

Cochrane, and Scopus were all searched using pertinent keywords, reference searches, and citation searches. The search terms utilized to comb through the database were “Diet,” “Minerals,” “Nutrition,” “Orthodontics,” and “Vitamins.”

### Data selection and coding

Two independent reviewers located the relevant papers using the right keywords in various databases and online search tools. The chosen articles were compared, and a third reviewer was brought in if there was a dispute.

After choosing the articles, the same two reviewers independently extracted the following data: author, year of publication, country, kind of publication, study topic, population demographics (n, age), outcome measure(s), relevant result(s), and conclusion(s). The data were compared, and any differences were discussed with the third reviewer.

### Risk-of-bias assessment

The A Measurement Tool to Assess systematic Reviews (AMSTAR)-2 technique<sup>[18]</sup> was used to evaluate

the risk of bias in the studies we chose. AMSTAR-2 joins many other instruments that have been released for this purpose as a critical evaluation tool for systematic reviews. As seen in Table 2, it is a 16-point checklist. Two instruments that have drawn a lot of attention served as the foundation for the creation of the original AMSTAR tool. The original AMSTAR was duplicated in two newly produced instruments. The AMSTAR-2 risk-of-bias items identify the domains specified in the Cochrane risk-of-bias instruments for systematic reviews. In each case, these indicate an agreement that was achieved after input from more than 30 methodology experts.

### Statistical analysis

After selecting data on the sample size, variables analyzed, and various elements of the investigations, the data were then entered into the RevMan 5 program for

meta-analysis. Forest plots illustrating the odds ratio for different study methodologies were obtained as part of the meta-analysis for our study as shown in Figures 2-4.

## Results

The study design, methodology employed, description, and outcome are mentioned in Table 2. The results of the meta-analysis are provided in Figures 2-4.

## Discussion

According to the literature, a patient's dietary state may have an impact on how their tissues respond to orthodontic forces. For instance, the ascorbic acid shortage is thought to delay orthodontic tooth movement by reducing the body's capacity for healing. Too little

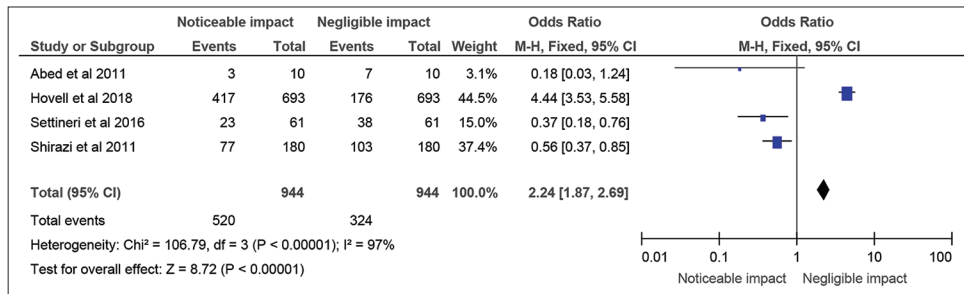


Figure 2: Odds ratio of randomized control trials and qualitative studies selected in this systematic review that assessed the impact of dietary habits and nutrition on orthodontic treatment represented on a forest plot after meta-analysis

Table 1: AMSTAR-2 16-point checklist of risk-of-bias assessment in studies selected for the systematic review

Studies selected	Question and inclusion	Protocol	Study design	Comprehensive search	Study selection	Data extraction	Excluded studies' justification	Included study details
Abed et al. 2011 <sup>[19]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Ashish et al. 2017 <sup>[20]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Hovell et al. 2018 <sup>[21]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Ibraheem et al. 2021 <sup>[22]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Maheshwari et al. 2017 <sup>[23]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Mehta et al. 2020 <sup>[24]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Bose et al. 2021 <sup>[25]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Settineri et al. 2016 <sup>[26]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Shirazi et al. 2011 <sup>[27]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No
Singh et al. 2017 <sup>[28]</sup>	Yes	Yes	Yes	Yes	Yes	No	No	No

Studies selected	Risk of bias	Funding sources	Statistical methods	Risk of bias in meta-analysis	Risk of bias in individual studies	Explanation of heterogeneity	Publication bias	Conflict of interest
Abed et al. 2011 <sup>[19]</sup>	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Ashish et al. 2017 <sup>[20]</sup>	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Hovell et al. 2018 <sup>[21]</sup>	Yes	N/A	Yes	N/A	Yes	Yes	Yes	Yes
Ibraheem et al. 2021 <sup>[22]</sup>	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Maheshwari et al. 2017 <sup>[23]</sup>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mehta et al. 2020 <sup>[24]</sup>	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bose et al. 2021 <sup>[25]</sup>	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Settineri et al. 2016 <sup>[26]</sup>	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Yes
Shirazi et al. 2011 <sup>[27]</sup>	Yes	N/A	Yes	N/A	Yes	Yes	Yes	Yes
Singh et al. 2017 <sup>[28]</sup>	Yes	N/A	Yes		Yes	Yes	Yes	Yes

**Table 2: Description and outcomes as observed in the studies selected for the systematic review**

Author and year of study	Sample size	Study design	Study objective/description	Study inference/outcome
Abed <i>et al.</i> 2011 <sup>[19]</sup>	10 adolescents (mean age 13.21 years; 4 males)	Qualitative interview-based study	The purpose of this study was to evaluate how fixed orthodontic treatment affected dietary intake and behavior. By conducting semi-structured one-on-one interviews with 10 adolescent patients receiving fixed orthodontic treatment—with a mean age of 13.21 years—the study used a qualitative methodology. By applying framework principles to identify emerging themes and ideas, the interviews were transcribed and analyzed by two separate researchers.	The two primary themes arising in adolescent patients receiving fixed orthodontic treatment were pain experience and dietary change, according to framework analysis. During the first few days of treatment, all patients complained of varying degrees of pain; however, after that, it was observed to lessen. All patients acknowledged that their diets had changed as a result of pain, difficulty chewing and biting, and dietary recommendations made by their orthodontist. Patients believed that after receiving treatment, their eating habits had improved. The study made clear the need to investigate dietary modifications across a wider population base.
Ashish <i>et al.</i> 2017 <sup>[20]</sup>	-	Literature review	By conducting this literature review, the authors hoped to shed light on the relationship between dietary habits and the orthodontic treatment the patient received, and how nutrition may play a crucial role in enhancing the likelihood that the orthodontic therapy will be successful.	The physicians remarked that it could have been advantageous to offer dietary assistance to orthodontic patients in selecting soft food diets to optimize patients' physiologic response to orthodontic therapy. This involved gathering nutritional history, assessing the diet, enlightening the patient about diet elements crucial to dental health, inspiring the patient to improve diet, and providing follow-up to assist the patient in changing their eating habits.
Hovell <i>et al.</i> 2018 <sup>[21]</sup>	693 children (8-14 years old)	Randomized control trial	The authors enlisted orthodontic offices in Southern California and Tijuana, Mexico, and enlisted their patients aged 8 to 16 to participate in a two-year study to conduct a randomized controlled trial to determine whether brief exercise and dietary advice given during child patient visits their orthodontic office could improve diet, physical activity, and age- and gender-adjusted BMI. The staff gave the kids "prescriptions" for bettering their eating and activity habits at each visit to the office.	Although the authors highlighted that orthodontists might give non-dental preventative counsel to complement other health practitioners' recommendations, the intervention, which was based on the Geoffrey Rose model, had minimal success in reaching its goals. To adequately examine the effectiveness of clinician-based brief counsel on preventing child obesity and/or reversing obesity, higher integrity to trial design was required.
Ibraheem <i>et al.</i> 2021 <sup>[22]</sup>	-	Literature review	This review was created after searching and compiling articles from 1930 to July 2021. It emphasizes different food types that should be consumed during fixed orthodontic therapy and explains the impact of different foods and beverages on the growth and development of craniofacial structures, tooth surfaces, root resorption, tooth movement, retention, and stability after orthodontic treatment, as well as the impact on the components of fixed orthodontic appliances.	The authors noted that it might be helpful to offer dietary advice to the patient to optimize their physiological reactions to orthodontic treatments. This could be done by obtaining their nutritional history, assessing their diet, teaching them about the diet elements that are crucial for oral health, inspiring them to improve their diet, and then following up to support their efforts to alter their eating habits.
Maheshwari <i>et al.</i> 2017 <sup>[23]</sup>	-	Literature review	The authors of this study believed that specific dietary considerations and recommendations were essential for the patient's overall health and the success of the treatment, so they provided an overview of the relationship between diet and orthodontic treatment, including orthognathic surgeries.	According to the authors, it could have been advantageous to give the orthodontic patients proper food advice to maximize their physiologic response to the orthodontic therapy. To support patients' efforts to alter their eating habits, practitioners needed to assume responsibility for gathering nutrition history, evaluating the diet, educating the patient about diet components and their significance for oral health, motivating the patient to improve their diet, and following up.

Contd...

Table 2: Contd...

Author and year of study	Sample size	Study design	Study objective/description	Study inference/outcome
Mehta <i>et al.</i> 2020 <sup>[24]</sup>	-	Literature review	The authors' objective in performing this literature review was to establish a connection between dietary practices and the orthodontic therapy the patient underwent and how nutrition may be a key factor in increasing the likelihood that the orthodontic therapy would be effective.	It was advised that dietary advice be given to orthodontic patients in choosing soft food diets, which included obtaining nutrition history, evaluating the diet, and educating the patient about diet components important for oral health. Adequate nutrition allowed proper healing response during applied orthodontic forces that optimized the patient's physiologic response to orthodontic treatment.
Bose <i>et al.</i> 2021 <sup>[25]</sup>	-		Through this review, the authors sought to learn more about the role that dietary management plays in an orthodontic procedure that lessens the likelihood that the orthodontic appliance will be harmed. They thought it was advantageous for both the orthodontist and the patient undergoing treatment, as well as convenient for the orthodontist.	The authors noted that the key to successful orthodontic treatment was following an orthodontist's recommended diet. Less breakage of orthodontic attachments, which was the most frequent mistake experienced by orthodontists, resulted from teaching a patient receiving orthodontic treatment about his or her diet.
Settineri <i>et al.</i> 2016 <sup>[26]</sup>	61 adolescents (mean age 15.6 years)	Correlational study	The study's objective was to examine the connection between the psychological effects of orthodontic treatment on adolescents' levels of self-esteem and any potential relationships with their eating patterns. 61 teenagers between the ages of 12 and 22 took part in the study. The Eating Attitudes Test, the Rosenberg Self-Esteem Scale, and the Psychosocial Impact of Dental Aesthetics Questionnaire were used in interviews with each adolescent.	Although the data could not directly link eating disorders to dental aesthetics, adolescents undergoing orthodontic treatment, particularly in the early stages of donning braces, had odd eating habits and experienced a greater psychological impact of dental aesthetics. Eating habits and overall self-esteem were directly related.
Shirazi <i>et al.</i> 2011 <sup>[27]</sup>	180 individuals (15-17 years old)	Randomized control trial	180 patients between the ages of 15 and 17 participated in this study, 90 of whom were in the study group and 90 of whom were controls. The primary goal of the study was to compare the nutrient intakes of adolescents wearing fixed orthodontic appliances and a control group matched for age and gender. A 24-hour recollection recall was used to evaluate nutritional intake, and demographic information was gathered using questionnaires.	Orthodontic patients consumed about the same total calories, protein, and carbohydrates as the control group did, but they consumed more total fat, saturated fat, monounsaturated fat, polyunsaturated fat, linolenic fat, linoleic fat, and cholesterol. They also consumed significantly less fiber, chromium, and beta-carotene. Other macro- and micronutrient intake did not vary considerably between the groups.
Singh <i>et al.</i> 2017 <sup>[28]</sup>	-	Literature review	The authors of this research discussed the connection between nutrition and orthodontic therapy because they thought that a balanced diet was essential for successful orthodontic treatment and should be taken into account by both the patient and the orthodontist.	The authors pointed out that to improve the patient's physiological responses to orthodontic treatments, it would be beneficial to provide nutritional recommendations. This could be achieved by learning about their nutritional background, evaluating their diet, educating them about the diet components that are important for dental health, motivating them to change their diet, and then following up to support their efforts to adjust their eating patterns.

BMI: Body mass index

ascorbic acid prevents collagen from breaking down and reforming, which is important for tooth movement.<sup>[4,29]</sup> Ascorbic acid levels in orthodontic patients range from 17% to 72% below ideal.<sup>[29,30]</sup> Although there is little literature on how orthodontic treatment affects a patient's diet and even fewer reports on specific diet guidelines for orthodontic patients, orthodontists

frequently advise their patients to eat soft foods during treatment to accommodate pressure sensitivity experienced with tooth movement.<sup>[31]</sup> However, there is not much mention of how orthodontic treatment modalities are affected by the nutritional patterns of the patients using orthodontic appliances. To date, we discovered only three randomized clinical trials that

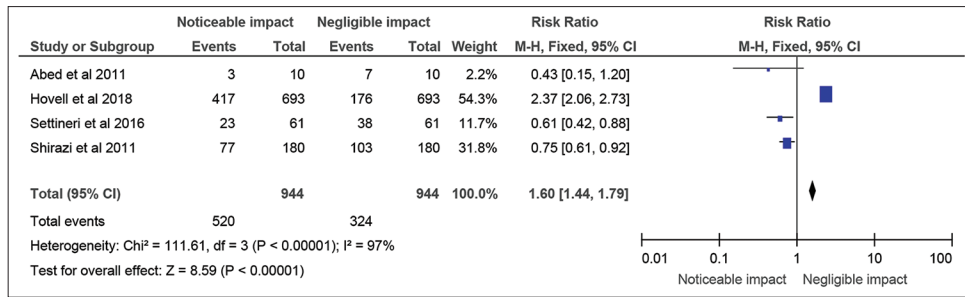


Figure 3: Risk ratio of randomized control trials and qualitative studies selected in this systematic review that assessed the impact of dietary habits and nutrition on orthodontic treatment represented on a forest plot after meta-analysis

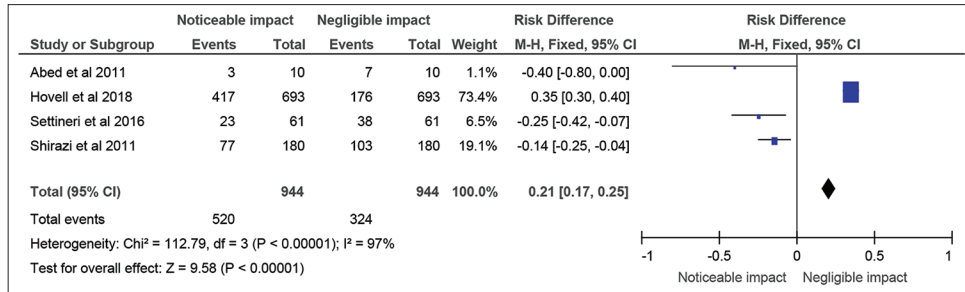


Figure 4: Risk difference in randomized control trials and qualitative studies selected in this systematic review that assessed the impact of dietary habits and nutrition on orthodontic treatment represented on a forest plot after meta-analysis

discussed the direct correlation between orthodontic treatment and nutritional profile.<sup>[21,27,32]</sup>

Sean Beattie *et al.*<sup>[33]</sup> proposed that polymeric elastic bands serve as one of the foundations for orthodontic tooth movement by replicating the effects of daily diet and patient compliance with elastic band alteration. In contrast to using heavy force, using light force at the right rates allows for quick tooth movement during orthodontic therapy with the least amount of patient discomfort and mobility. Force degradation is influenced by lumen size, with smaller diameters requiring more frequent renewal to maintain the intended force application.<sup>[34]</sup> Studies have looked into the impacts of simulated saliva environments, pH, and thermocycling, in an effort to model different oral environments, on force degradation.<sup>[34-37]</sup> The simplest formulation of artificial saliva is 0.09% aqueous sodium chloride, which is frequently employed in experiments simulating the intraoral environment. In general, the data showed that after elastics were subjected to experimental circumstances, force significantly relaxed. During clinical use, orthodontic elastic bands are believed to degrade mostly as a result of mechanical forces.<sup>[37]</sup> Leachable moieties, however, have been isolated from a few orthodontic elastic bands, and their rising concentrations in solution correlated with a gradual loss of force.<sup>[38]</sup> The majority of the experiments on the deterioration of orthodontic elastic materials have been done in artificial saliva or air, although this topic has been studied.<sup>[36-38]</sup> However, dental polymeric restorative

materials' reactions to food-like oral environments have been researched. When polymeric restorative materials are exposed to ethanol/water, ethanol/artificial saliva, lactic acid, citric acid, and alcohol/water as simulated foods, several forms of degradation have been observed to be accelerated that include coffee, erythrosine, food colors, vinegar, Coca-Cola, whisky, and oranges.<sup>[39-41]</sup>

According to Gokhan Oncag *et al.*,<sup>[40]</sup> the study looked at how acidic soft beverages affected metal brackets' resistance to shear stresses both *in vitro* and *in vivo* and discovered that there was no statistically significant difference between the *in vivo* and *in vitro* groups in terms of debonding resistance. In both the *in vitro* and *in vivo* groups, areas of enamel surface defect brought on by erosion were seen close to the brackets. Coca-Cola and Sprite are examples of acidic soft beverages that negatively affect bracket retention against shearing pressures and enamel erosion.

Shimizu *et al.*'s<sup>[41]</sup> investigation on changes in the upper and lower alveolar bones' skeletal microstructure after masticatory loading brought on by feeding growing rats a soft diet. The findings show that in rats with modest masticatory stress throughout growth, alveolar osteopenia is more severe in the mandible than the maxilla.

The lack of randomized control trials can be attributed to being a major flaw in this systematic review of ours; however, the topic of nutrition and its correlation with orthodontic treatment/management modalities has been

very poorly represented and quite under-researched in the literature as we observed. Also, a ton of literature/scoping reviews exist on this topic, which we believe do not paint an accurate picture since they lack evidence of a correlation between orthodontic treatment and dietary patterns. Hence, we believe that more studies are needed to ascertain the link between the two factors so that credible, fact-based recommendations can be devised that are beneficial for the patients undergoing treatment.

## Conclusions

This systematic review found a very weak correlation between the nutritional intake of patients and its impact on their orthodontic treatment. Also, since most of the studies mentioned only noticed an impact during the beginning phase of the treatment, a direct causal link between the two could not be established credibly. Hence, we believe more studies are needed in this regard and we believe orthodontic patients should receive nutritional counseling, and enlisting the assistance of a nutritionist may be beneficial.

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## Conflicts of interest

There are no conflicts of interest.

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