

# Implants for orthodontic anchorage. Meta-analysis

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## SUMMARY

The purpose of this article was to review and update current data of the use of implants for orthodontic anchorage. A meta-analysis of selected literature was carried out and a total of 415 articles were identified in this process. Having reviewed the articles or their abstracts/summaries the data were evaluated and the articles were categorized according to the journal and the year of publication, the type of the article and the type of the implant. The interest in the possibilities of the implant usage for orthodontic anchorage is noticeably increasing and today it has reached the peak. In order to facilitate the understanding of the wide range of implants, we suggested the classification of the implants for orthodontic anchorage according to the shape and size, the implant bone contact and the application of the implant. We systemized the information about types of implants and their advantages in respect of traditional orthodontic treatment.

**Key words:** meta-analysis, orthodontic implant, absolute anchorage.

## INTRODUCTION

The selection of a proper anchorage is an essential factor for the successful orthodontic treatment. Every orthodontic device, which exercises a force onto the tooth, generates an opposite force which then affects the anchorage. The implant in the bone remains stable, which ensures a secure anchorage when no teeth are used.

According to the point of force application anchorage may be direct or indirect. Intraoral extradental anchorage systems also may be classified on the dependency or lack of osseointegration [1]. Implant anchorage (called skeletal or absolute anchorage) seemed to open a new era in orthodontic biomechanics. Gainsforth and Higley suggested using metallic screws as anchors as long as 1945 [2]. Following the successful use of conventional prosthodontic implants, osseointegrated implants were used for intraoral orthodontic anchorage. Creekmore and Eklund in 1983 were the first to introduce screws in clinical orthodontics for the sole purpose of orthodontic anchorage [3]. In the 1990s, surgical screws (also referred to as mini-screws, mini-implants and micro-screws) increasingly were used to provide anchorage for orthodontic tooth movement. Both animal and human studies provided a basis for their clinical use. The purpose of this article was to review and update current data of the use of implants for orthodontic anchorage and classify them in order to make the orientation within the great variety of implants easier.

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## MATERIAL AND METHODS

In order to ascertain the possibilities of implant usage in orthodontics, a meta-analysis of selected literature was carried out. Meta-analysis provides a method of equating and eventually comparing results of several independent studies on a specific topic. It is a technique that permits analysis and comparison of research data from diverse sources [4]. Meta-analysis is the application of statistical procedures to collections of findings from individual studies for the purpose of integrating them, using results from existing studies to reveal patterns of underlying relations.

The literature was selected using the online database of Pub Med. The search was conducted using the keyword orthodontic implant.

The choice of the articles was not influenced by the year of their publishing. Abstracts and summaries of these articles were reviewed to select papers. To minimize the chance of omitting any relevant literature, the first step of the screening procedure was performed again in 6 months interval. In addition to the computer search, the reference list for selected articles was examined to identify the articles that were not retrieved by the Pub Med search. All the articles in English were selected. A total of 415 articles were identified in this process. To minimize inclusion of poor-quality studies, only refereed journals were examined. Having reviewed the articles or their abstracts/summaries the data were analysed. The articles were categorised according to the journal and the year of publication, the type of the article and the type of the implant.

## RESULTS

Having completed the search with the keyword orthodontic implant, 198 articles were selected according to the criteria mentioned above.

The reviewed articles were published in 35 different

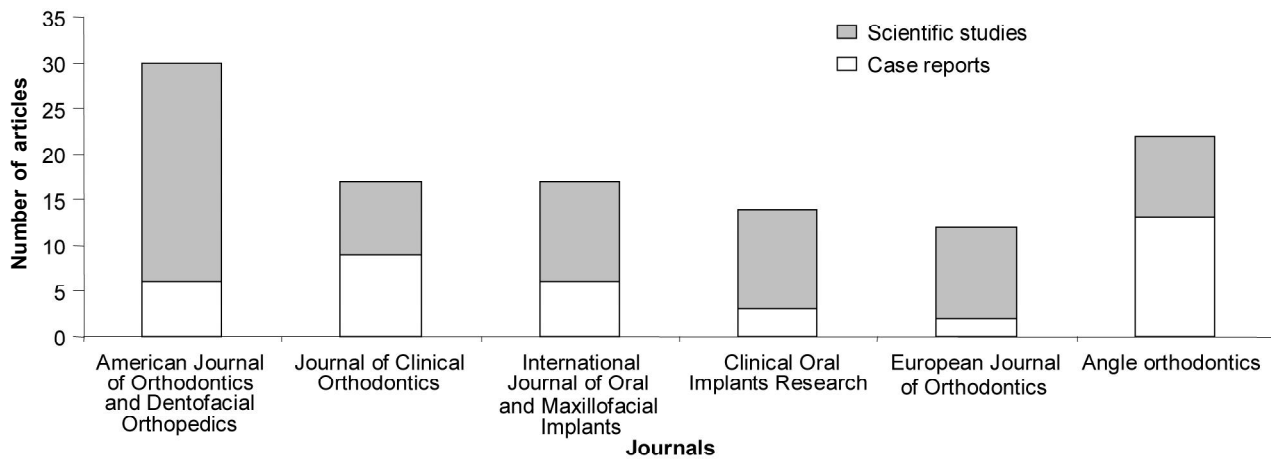


Fig. 1. The distribution of the articles according to the type in the main journals

journals. We noted six major journals, which published more than ten articles on the usage of implants in orthodontics. The type of the articles in the journals was different. Some tended to publish research studies (American Journal of Orthodontics and Dentofacial Orthopedics, Clinical Oral Implants Research), others focused more on practical aspects and clinical situations (Angle orthodontics) (Figure 1).

Up to 1995 there was a relatively small number of articles on the subject. However, later the interest in the possibilities of the implant usage was noticeably increasing and today it has reached the peak of its popularity (Figure 2).

As any other way of treatment the orthodontic implant systems have gone through a number of development stages. Firstly, the systems were tested on animals. The results of the experiments were analysed and only then applied in clinical practice. The period of the most

intensive animal testing was 1992-2000. However, tests are carried out further since a lot of questions remain unanswered (Figure 3).

The usage of prosthodontic implants was on the increase up to 2000, however, later it declined and prosthodontic implants were outnumbered by palatal and mini screw implants, which are widely used at the moment (Figure 4).

The same online research was carried out in interval of 6 months and the ratio of mini screw and prosthodontic implants significantly shifted within this short period, which only confirms the assumption of the popularity of the small implants (Figure 5).

In order to facilitate the understanding of the wide range of implants, we would suggest the following classification of the implants for orthodontic anchorage:

- I. According to the shape and size:
  - 1) Conical (cylindrical):

Table 1. Comparison of orthodontic and prosthodontic implants

	Prosthodontic implants	Orthodontic implants			
		Mini screw implants	Palatal implants	Mini plate implants	Onplants
1. Anatomic sites for implantation	Alveolar process of maxilla and mandible, zygomatic process of maxilla	Every structure, where there is enough cortical bone	Median suture of the palate, paramedian	Every structure, where there is enough cortical bone	Median suture of the palate, paramedian
2. Patient's age	Not used until 18 years of old, because of skeletal growth	There are no age contraindications	Used after ossification of median suture of the palate	There are no age contraindications	Used after ossification of median suture of the palate
3. Time of loading	Loading after osteointegration is complete (3-6 months)	Immediate loading	Loading after osteointegration is complete (3-6 months)	Loading after healing	Loading after osteointegration is complete (3-6 months)
4. Type of surgery	Flap surgery and bone preparation is needed	Only perforation of the mucosa is needed	Perforation of the mucosa and bone preparation is needed	Flap surgery is needed	
5. Postsurgical period	Pain and swelling remains for a week	Minimum of patient's discomfort		Pain and swelling remains for a week	
6. Use	For orthodontic anchorage and orthopaedic purposes	For orthodontic anchorage, removed after treatment			
7. Size	2,9-6mm diameter, 6-18mm length	1,2-2,3mm diameter, 6-14mm length	3,3mm diameter, 4-6mm length	2mm diameter, 5mm length (screw)	10mm diameter, 2mm thickness

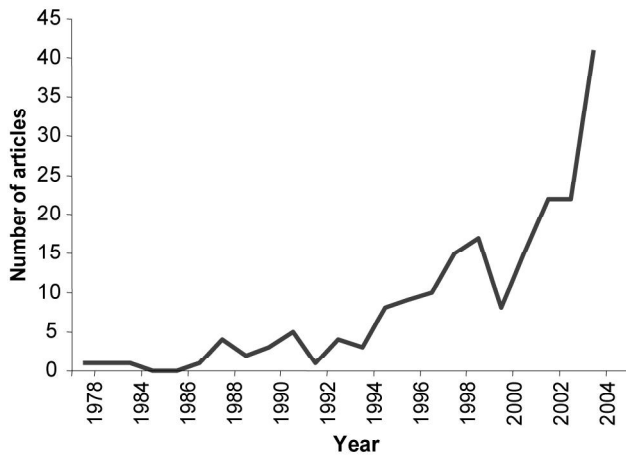


Fig. 2. Articles on the subject of orthodontic implants

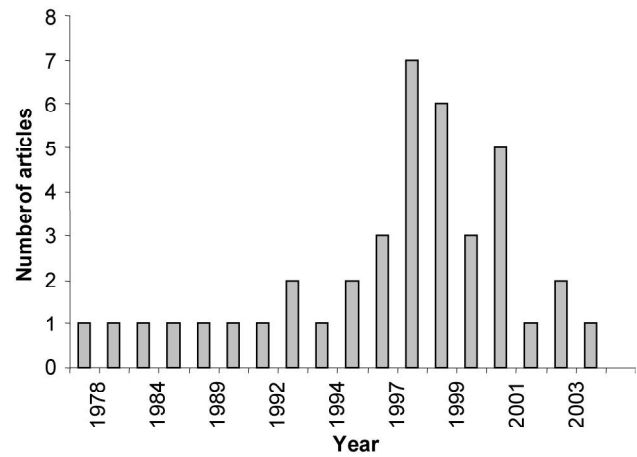


Fig. 3. Articles on the subject related with animal studies

- a) mini screw implants;
- b) palatal implants;
- c) prosthodontic implants;
- 2) mini plate implants,
- 3) disc implants (onplants).
- II. According to the implant bone contact:
  - 1) Osteointegrated;
  - 2) Non-osteointegrated .
- III. According to the application:
  - 1) Used only for orthodontic purposes (orthodontic implants);
  - 2) Used for prosthodontic and orthodontic purposes (prosthodontic implants).

In order to answer the questions about the choice of implant treatment and which type applies to a particular clinical situation, we systemized the information about types of implants and their advantages in respect to traditional orthodontic treatment. The results are presented in the following tables (Table 1 and Table 2).

**DISCUSSION**

Implants for orthodontic anchorage are quite a new research area. Scientists hold different opinions on most of the questions, therefore more sophisticated and detailed analysis is needed in order to come to a unanimous

truth. Firstly, prosthodontic implants were used for the orthodontic purpose. At the time they were the only type of implants used in dentistry, their application in orthodontics dates back to the late 70s.

However, the usage of these implants is rather limited due to their size, time consumption for osteointegration, etc. For various clinical situations several treatment methods can be applied; it is possible to choose different implant systems and positions of screwing. The latter fact led to the invention and increasing research of new implant systems, such as, palatal or mini screw implants. Due to simpler biomechanics, small size, non-invasive surgery they have become increasingly popular. The research on the subject is on the increase and the small implants are used more and more widely replacing the bigger ones. The interest in the possibilities of the implants in orthodontics is noticed not only among the orthodontists but also among surgeons, as specialists of both types are required in the process of the implant treatment. With the invention of new implant systems the implantation methods need to be improved and newly risen questions need to be answered.

The smaller the implant the less surgical invasion is needed, the lighter swelling and pain and, thus, the discomfort. The smaller implant, however, has a smaller area of osteointegration, which limits the possible forces to

Table 2. Comparison between treatment using orthodontic implants and traditional orthodontic treatment

	Traditional orthodontic treatment	Orthodontic treatment using implants
1. Anchorage	Teeth, extraoral bony structures	Implants
2. Stability of anchorage	Position of anchor teeth is not stable during treatment	Position is stable during treatment
3. Number of anchor teeth	In order to get sufficient anchorage- more teeth must be included	For direct anchorage teeth are not necessary, minimal number of teeth are needed for indirect anchorage
4. Treatment efficiency	Applying force on teeth, part of it is wasted, due to periodontal amortization	Applying force on implant it is directly transferred to the moving part of orthodontic system
5. Duration of the treatment	There is no reliable anchorage for transferring the desirable number of teeth at once - treatment time elongates	Stable anchorage enables transferring maximal number of teeth at once - treatment time shortens
6. Patient's cooperation	Obligatory	Minimal
7. Treatment acceptability	Most of treatment devices restrict patient's motions, don't meet esthetical requirements	Discomfort for the patient is minimal
8. Professionals	Orthodontist	Orthodontist and Oral surgeon
9. Side effect	Undesirable change of anchor teeth position	No side effect mentioned in reviewed literature

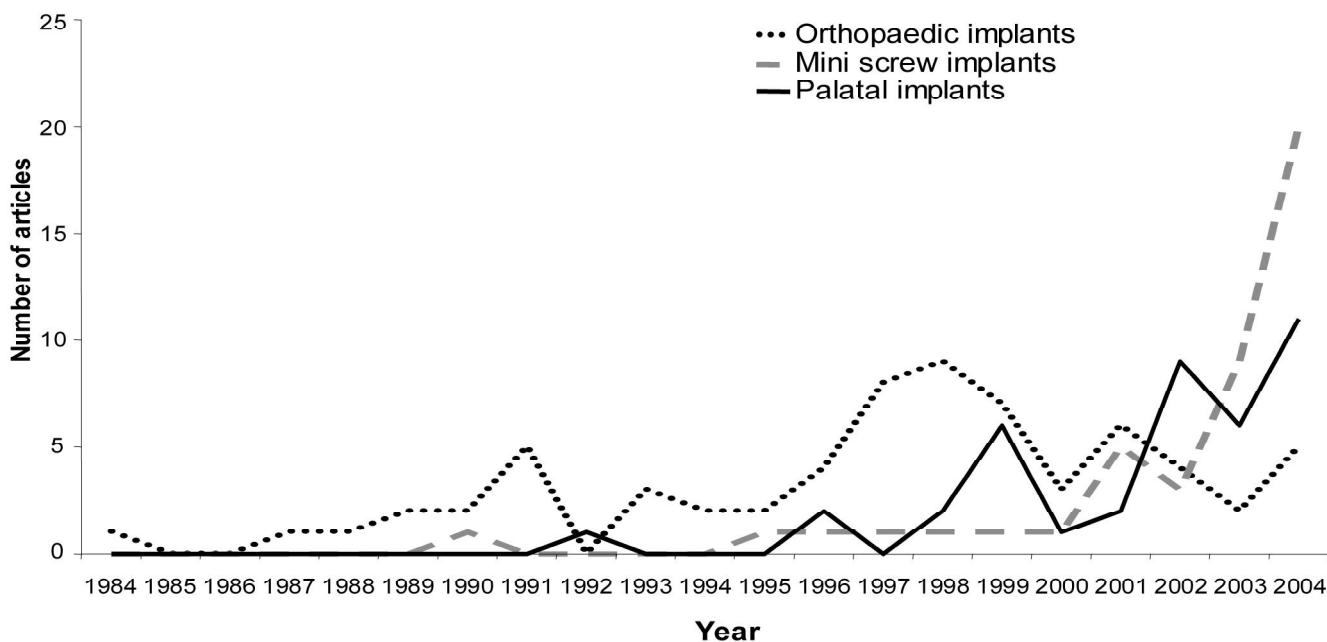


Fig. 4. Distribution of articles according to the type of the implant and the year of publication

apply on the implant. Miyawaki et al. reveals that implants 1mm in diameter are the least reliable [5]. There is no major statistical difference between other mini screw implants. If an implant is longer than 5mm it does not affect the stability [5]. Kanomi argues that smaller and rather short implants serve the purpose as well, however, due to the cut in length the primary stability is reduced, which then has to be recovered by the stabilising edge and threads [6]. Miyawaki et al. and Umemori et al. claim that mini plates fastened with two mini screw implants are a nearly 100% success [5, 7]. Therefore, as far as stability is concerned, mini plates have an advantage over screw implants, however their insertion rests on invasive surgery, which causes discomfort for the patient. Moreover, not all anatomic areas are suitable for putting in plates. The smaller the implant is the bigger number of anatomic structures for possible screwing.

The implants can be screwed not only in the alveolar process or the palate, but also in other places of the face and jaws bone structures. Singer et al. has used prosthodontic implants screwed in maxillo-zygomatic suture [8]. But can an invasive surgery such as an implant screwing in the anterior nasal spine [3,9,10] or maxillo-zygomatic suture [3,10,11] for orthodontic purposes be justified? Those methods are not the most frequent since they are hardly borne by patients. According to some authors, however, this is the only alternative to achieve positive treatment results [8,12]. They have used implants on growing patients in order to encourage skeletal growth and got positive results, although the majority of the authors claim that the implant in a growing body can hinder the bone development. According to Singer et al. the facemask treatment and the usage of implants as an anchorage are more effective than the usage of teeth as an anchorage, because the pressure directly affects the actively growing bone structures [8].

It takes 4-6 months for the full-fledged bone and im-

plants coalescence to form [10,13-15]. However, there is a question whether a full implant osteointegration is needed in orthodontics when relatively small forces are applied. An implant screwed, the embracing bone tissue is structurally weak, and thus, to load it a total osteointegration process is required. [10]. Other authors state that the load time does not affect the stability because the primary implant stability is sufficient for orthodontic treatment. [5]. More over these implants are easier to remove after orthodontic treatment [9,10]. Miyawaki et al. research proves that the force can be applied straight away if the force is under 2N [5].

A unanimous and generally acknowledged classification of orthodontic implants was not found in the reviewed literature. Different authors use distinct implant types for the treatment of the same clinical situations. For instance, to achieve bodily movement of teeth in mesiodistal direction mini screw, palatal, prosthodontic implants and onplants can be used; for dental intrusion - mini screw, plate implants. However, there is no absolute instruction for the application of a certain type of implants. Theoretically several implant systems can be applied to each clinical situation. In practice, however, the decision on the implant type depends on the dentist competence and individual anatomic patient features. For example, in the case of an implant in the median palatal suture the majority of specialists choose a screw palatal implant. Block and Hoffman and Janssens et al. alternatively suggest the use of a subperiosteal disc implant because the insertion of a screw implant in the palatal area might lead to the perforation of nasal cavity [16,17].

For dental intrusion Park et al. has used mini screw implants [18], whereas Umemori et al., Sherwood et al. suggest using mini plates on the grounds of their extensive stability and the ability to sustain bigger forces [7,19]. On the other hand, mini screw implants require less surgical intervention consequently causing less discomfort to the patient.

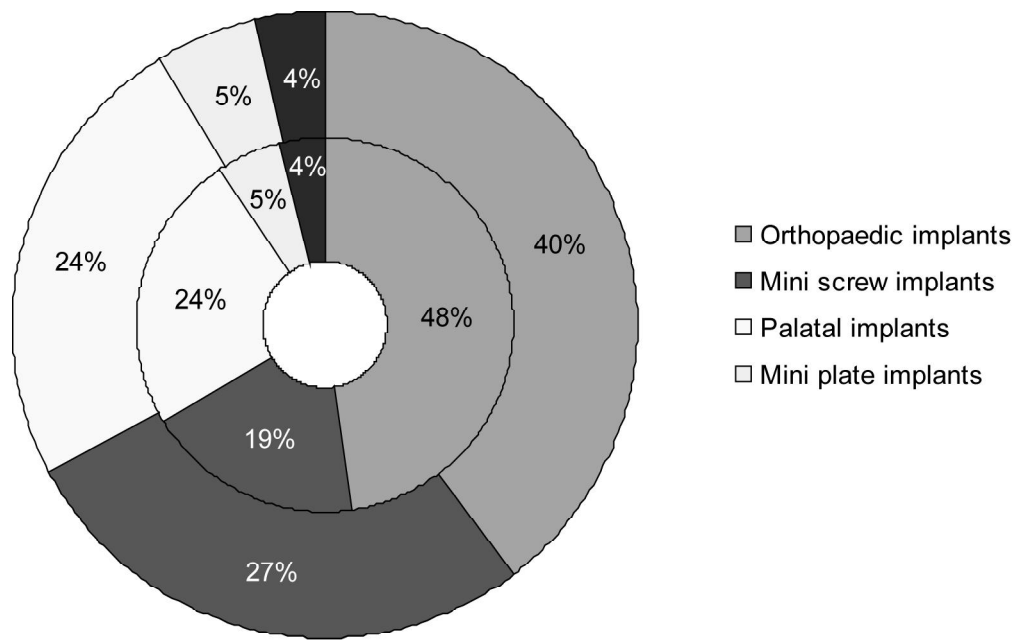


Fig. 5. The distribution of articles according to the type of implants. The outer circle shows data after six months

The implant treatment is shorter and more effective, but can it oust the more traditional orthodontic anchorage methods? A considerable number of orthodontists successfully resort to the usual treatment methods and sceptically view the use of implants. Patients do not appreciate the surgical intervention and the implant in the mouth, let alone the higher treatment cost. Despite the latter fact, we think that the implant treatment method will prevail in the future and play a significant role in orthodontics.

## CONCLUSIONS

1. The orthodontic treatment using implants is a new method, doctors are not enough acquainted with it and implant systems are not standardized.
2. Orthodontic treatment using implants is almost 100% successful, if the right type of implant selected and the clinical situation properly evaluated.
3. Implants are an excellent alternative to traditional anchorage methods in orthodontic treatment.

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