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A systematic review of the role of implant design in the rehabilitation of the fully edentulous maxilla

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The contents of this paper was presented in a plenary session of the Academy of Osseointegration summit meeting, Chicago, August 7th, 2014.

Abstract:

Purpose: to identify and critically appraise scientific publications evaluating the possible effect of implant design on treatment outcomes in the rehabilitation of the fully edentulous maxilla.

Materials and methods: Scientific reports were sought in three electronic bibliographic databases, combined with searches for meeting abstracts and in the grey literature. All scientific publications in English, German or Scandinavian reporting prospective or retrospective longitudinal studies with effects of an implant design feature on the treatment outcomes were eligible. The minimum requirement for inclusion was at least 10 study participants and followed for at least two years after their rehabilitation. The PRISMA guidelines were followed for selecting relevant data to extract from the individual studies. These were characteristics of the individual studies, risk of bias within the individual studies and the results of individual studies.Three editorial teams independently identified and extracted the data.

Results; The search resulted in 998 primary studies, of 525 met the inclusion criteria and were read in full text. Of these, 105 studies were included in qualitative syntheses. Seventeen of these were designed with an objective to assess effects of implant design or -feature on outcomes, 23 studies reported effects of tilted implants to enable placement of longer implants, 30 studies reported effects of implants placed in zygomatic bone with or without additional alveolar implants and 9 reported effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants. Sixteen papers reported bone augmentation with simultaneous or delayed implant placement in patients with predominantly Cawood-Howell bone class V and VI maxilla. Finally, 10 papers reported effects of implant design on outcomes, in spite of lack of an a priori stated objective to assess a particular implant design or feature. There is a lack of compelling data to state that one particular implant system or design feature stands out amidst others, when applied to restoring the fully edentulous maxilla with implant-retained prosthetics.

Conclusions: This systematic review failed to identify compelling evidence to conclude that any particular implant or feature affects the outcome of the treatment of patients with a fully edentulous maxilla

Key words: dental implants; Dental Implantation, edentulous jaw; Endosseous; implant supported dental prostheses; Stomatognathic System;

Individuals with a fully edentulous maxilla frequently report low social self-confidence and related low quality of life due to compromised oral functions and poor esthetics. The majority may benefit from the relatively low cost technical solution of a correctly designed removable dental prosthesis individually fitted to the remaining oral tissues, which can restore to a certain level both oral functions as well as the facial and oral appearance.[1] Many, however, are unable to adapt to a more or less removable dental prosthesis. This could be attributed to specific conditions of general or oral health, to compromised local anatomy that impedes optimal prosthesis design or merely due to psychological barriers.[2] The introduction of endosseous titanium dental implants has provided a more predictable alternative than a conventional removable prosthesis to restore the patient's facial appearance and oral functions with a dental device retained or supported by these root-analogues.[3]

With the high predictability to re-establish oral functions and aesthetics with implant-supported prostheses, new dental implant designs and material compositions have increased rapidly. The number of dental implant brands on the market was 45 systems in 1988,[4] 98 systems in 2000,[5] 225 systems from 78 manufacturers in 2002[6] and 600 systems from 146 manufacturers in 2008.[7] Currently, there are at least 364 dental implant manufacturers producing an estimate of 1600 different implant systems. Distinct minorities of these implant manufacturers have undertaken basic, animal and human research when designing new or altering the components of existing implant systems. Consequently, many currently commercially available dental implants have insufficient, questionable or simply totally lacking scientific justification of the product designs and material compositions. This is even more profound when we are seeking high quality long-term evidence. Potential alterations of the implant design include both its macro-geometry as well as its surface micro-topography, which transforms surface chemical and biochemical properties, corrosion characteristics and wear debris release, surface energy and wettability as well as topography on micrometer and nanometer scales.[8, 9, 10]

It is uncertain whether one particular implant design is the optimal for the fully edentulous maxilla. It is also doubtful whether one may extrapolate data from other clinical scenarios, such as in single implants or implant-supported small FDPs in partial edentate jaws. The main objective of this systematic review was to identify and critically appraise scientific publications evaluating the possible effect of implant

design on treatment outcomes in the rehabilitation of the fully edentulous maxilla. A secondary objective was to provide the basis for the development of evidence-based clinical guidelines for best management of patients with a fully edentulous maxilla. (See separate sections in the IJOMI supplement)

Materials and Methods

Protocol and registration

The AO 2014 Summit organizing committee determined the topic for this systematic review in July 2013 and established a task group to develop the PICO question, the criteria for study eligibility and to conduct the reviewing process. An intra-net website hosted by the University of Iowa served for sharing all relevant evidence and as communication tool for the task group.

Focused question

The task group developed the following PICO question: For patients with a fully edentulous maxilla who desire an implant-supported prosthesis, does the implant design affect the following outcomes: crestal bone loss or implant failure, patient satisfaction, biological and technical adverse events of implant and prosthesis, including surgical complications, maintenance needs and cost aspects?

Eligibility criteria

We considered all scientific publications reporting longitudinal studies that included the use of more than one implant system as eligible. Also eligible were reports with an abstract containing any suggestion of any effects of an implant design feature on the treatment outcomes. The minimum requirement for inclusion was that the report described at least ten study participants with a fully edentulous maxilla restored with an implant-retained or -supported prosthesis and followed for at least two years after their rehabilitation. The selected minimum follow-up time and cohort size was determined as a trade-off between the required time and resource allocation for conducting this systematic review versus the clinical relevance of the length of the follow-up time. We considered both prospective and retrospective study designs published in full publications and/or meeting abstracts in the scientific and in the grey literature. These reports were restricted for logistical reasons to English, German and Scandinavian languages (Danish, Norwegian and Swedish).

We read in full the identified reports if it was not made clear in the abstract whether the general term “edentulous” encompassed study participants with a fully edentulous maxilla. Reports were not included for consideration if the research focus was on post-restoration interventions of adverse treatment outcomes, e.g., of peri-implantitis, dehiscence, fenestration, repairs, etc or pre-implant augmentation interventions with no further reporting of outcomes of implants or supraconstruction. Moreover, this review does not include patients undergoing reconstructions due to extensive loss of oro-maxillo-facial tissues, e.g., caused by trauma, cancer or congenital defects.

Information sources

Scientific reports were sought in three electronic bibliographic databases; MEDLINE though Pubmed (www.pubmed.com, National Library of Medicine), The Cochrane Central Registry of Controlled Trials (www.thecochranelibrary.com, Wiley Blackwell), and EMBASE via OVID (www.embase.com, Elsevier). We searched for clinical research not yet published in full text, or remaining unpublished in the abstract database of the International Association for Dental Research (iadr.confex.com/iadr/search.epl). We searched also for potential clinical studies published in the grey literature or elsewhere through Google Scholar. We conducted the latest search on June 30th, 2014, and went back to 1965, or the earliest records of the electronic bibliographic databases.

Search strategy

We adopted the key words and MESH terms from a recent systematic review on the prosthetic rehabilitation of patients with edentulous jaws conducted by the Swedish Council on Health Technology Assessment (Table 1).[11] We modified the search strategy to fit the appropriate formats applicable to the different electronic bibliographic databases.

Reviews of the reference lists found in the identified relevant systematic reviews supplemented the search through the electronic databases (Tables 2a and 2b). We hand searched further to identify possible studies, also assessing recent issues of relevant scientific journals not yet recorded in the electronic databases. In addition, we used a personal indexed database of clinical studies related to oral implants and prosthetics built by the lead author containing over 4,500 references. Finally, we asked the individual experts of the task group to provide missing studies after having received tentative lists of identified publications for inclusion in the systematic review.

Study selection

Three independent teams, each consisting of two or three co-investigators, focused on one specific aspect of the implant design. The first focused on studies reporting on the role of overall implant body shape and thread design for the rehabilitation of the edentulous maxilla in healthy and medically compromised patients. The second focused on the role of implant length and diameter and the implant-abutment connection, while the third appraised the role of implant surface. Each team screened for study eligibility independently by using a common form and after completion, the teams swapped the topics and verified the previous search until reaching consensus. We planned to resolve potential disagreements by forced decision by the task group chairs, but no such situations arose.

Data collection process

The three teams conducted also independently the data collection process and resolved discrepancies by consensus. We did not contact the authors of the primary publications to obtain further data or to confirm extracted data.

We excluded reports if the outcomes of the individual implants were presented as a function of their lengths or diameters, when these implants supported a prosthetic restoration jointly with other implants having different geometries. We excluded also studies if we could not identify in the report the outcome specific to a fully edentulous maxilla as a function of the implant design characteristic, if subsequent follow-up data could replace the earlier data, or if we were unable to access the report as full text.

In situations with multiple publications from a single clinical study, we selected the one with the longest follow-up for data extraction. We appraised also the earlier reports if particular details about materials and methods were lacking in the primary report.

Extracted Data items

We followed the PRISMA guidelines when selecting relevant data to extract from the individual studies. These were characteristics of the individual studies, risk of bias within the individual studies and the results of individual studies, i.e. items #18 to #20 in the PRISMA checklist.[12] Characteristics of the individual studies included identification of the lead author and description of the study participants' condition, including the anatomy of the maxilla with regard to remaining bone (Figure 1).[13] Moreover, the years when the implants were placed and whether the study was

conducted in a single or multiple university, public health or private practice settings was recorded. The number of study participants and placed implants with the follow-up time was supplemented with the description of implant-type(s) with diameters and lengths. Details of the actual intervention included: (i) status of the pre-implant-surgery situation, (ii) implant surgery procedure details (iii) the protocols for immediate, early or delayed implant loading, and (iv) the type of supra-construction. Details of the treatment outcome included clinical, as well as patient-relevant outcomes such as satisfaction with esthetics and function and quality of life (Table 3).

Risk of potential bias in individual studies

Elements that possibly could limit the study internal and external validity included the study main objective and selected study design methodology, the number of participants and accrued number of implants, follow-up time in years, drop-out numbers, statistical tests and reported funding source.

We assessed potential bias by comparing contents against a list of criteria (Table 4) compiled from two quality-assessment tools used in recent systematic reviews.[14,15] These had in turn been derived from the Dutch Cochrane Centre and the Newcastle-Ottawa Scale respectively.[16] We separated publications that reported an *a priori* intention to appraise effects of any aspect of implant design on treatment outcomes from those containing no reference to this study objective, but still reported such findings. We considered it likely that the observations made this latter category of studies could be spurious, and the paper therefore probably more prone to bias than the studies designed for the purposes of appraising implant design effects.

We appraised the statistical methodology for appropriateness, in light of the stated study objective with particular emphasis to statistical test assumptions and choice of statistical unit. In addition, we recorded whether a formal ethics board or committee had approved the study protocol, and whether the authors declared a funding source of the study. We associated both criteria with lowered risk of potential bias. Formal statistical assessment to assess publication bias was not applied.

Summary measures

We planned this systematic review to present primarily descriptive data as a basis for the development of the clinical practice guidelines following the process described by Rosenfeld and Shiffman.[17] We considered using RevMan 5 (Nordic Cochrane Centre) for conducting meta-analyses if possible. Unfortunately, the yield of the

literature search was limited, and the reports too heterogeneous with regard to study methodology as well as clinical procedures and variables. Hence, no forest or funnel plots have been generated in this review. We recommend the reader to appraise the SRs listed in Tables 2a and 2b for meta-analytic data.

Results

Study selection

We identified approximately 1000 studies initially. After screening the abstracts, we considered that about half of these (n=473) were not eligible according to the *a priori* inclusion criteria. The predominant reason was a follow-up period of less than 2 years (n=340) or less than 10 study participants (n=91) or lacking both criteria (n=34) (Figure 2). The heterogeneous formats of the abstract and reporting of clinical outcomes precluded conclusive decisions about inclusion and exclusion so we had to scrutinize the full text of the remaining 525 papers. We selected about one fifth of these reports for data extraction (n=105). The major reason for exclusion was that the outcomes as a function of implant design aspects specific to a rehabilitated edentulous maxilla could not be identified in the report (n=382) (Figure 2). Further details on the non-included and excluded reports, including reasons for decision are located on the website of AO (www.xxxxxxx).

Within the overall PICO we identified 6 subcategories by an amalgamation of the pre-implant surgery characteristics of the study participants, combined with the complexity level and sequence of interventions (Table 5 and Figures 3-7).

Study characteristics

Studies designed with an objective to assess effects of implant design or particular feature on outcomes (Figure 3)

The literature search identified 196 reports, of which 77 were not included and 102 were excluded (Table 6). As many as 34 reports were from one study cohort, i.e., the extensive DICRG study undertaken by 30 Veterans Affairs Medical Centers across USA.[32] The predominant reason for non-inclusion was reported observation period less than 2 years (n=77), while the dominant reason for study exclusion was that outcomes as a function of implant design aspects specific to a rehabilitated edentulous maxilla could not be identified in the paper (n=79). A common experience was that reports with focus on “maxillary posterior atrophy”, with or without sinus grafting often failed to describe whether the study participants were partially or fully

edentulous. We selected 17 reports published between 1995 and 2013 for data extraction.[18-34]

The studies selected for data extraction included study participant cohorts that encompassed all categories of patient conditions[23,26,32] or only participants with edentulous jaws or an edentulous maxilla. Four studies included study participants with terminal teeth, who received immediate postextraction implants.[19,25,30,31]

The 17 reports presented results based on 3205 study participants with 12599 implants placed between 1987[34,35] and 2008[19]. The study settings were single private (n=6), university (n=6), public (n=2) or multicenter (n=3). The study cohorts ranged between 12 and 829[32] participants with 72 to 2955[32] implants, which were followed from two up to 15[21] years. The prevailing implant systems used were manufactured by Nobel Biocare (n=10), Astra Tech and Biomet 3i (n=3), Straumann (n=2), and Lifecore (n=1), Camlog (n=1), Dentsply (n=1) and CoreVent (n=1). Two studies did not report the name of the implant manufacturer.

Studies reporting the effects of tilted implants to enable placement of longer implants (figure 4)

The literature search identified 46 reports, of which 21 were not included and two were excluded since cylindrical implants were placed in healed sites, while all tapered were placed in postextraction sites. The most predominant reason for non-inclusion was lack of an observation period beyond 2 years (n=18). Twenty-three reports remained for data extraction, primarily with the intent to compare the outcome of the axial versus the (invariably longer) tilted implants (Table 7).[35-57]

The studies selected for data extraction were published between 1999[57] and 2014,[35-37] and included study participant cohorts that encompassed partially edentate or fully edentulous maxilla. Some of the studies focused on patients with a general or posterior maxillary atrophy. Twelve reports included study participants with terminal teeth, who received immediate postextraction implants, either or both axially placed or tilted. It was often difficult to judge whether some of the reports described outcomes of the same or separate study participant cohorts.

The 23 reports presented results based on 1516 study participants with 6681implants placed between 1991[55] and 2012[38]. The study settings were single private (n=8),

university (n=8), not reported (n=4), public (n=1) or multicenter (n=2). The study cohorts ranged between 15 and 242 participants with 68 to 995 implants, which followed from two up to 12 years. The prevailing implant systems used were manufactured by Nobel Biocare (n=15), Biomet 31 (n=2) and one each by Zimmer, Sweden&Martina and by Friatec/Friadent.Three studies did not report the name of the implant manufacturer. Separate outcomes as a function of different types or features of implants could be extracted from 5 reports.[42,46,47,48,52]

Studies reporting the effects of implants placed in zygomatic bone with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 5)

The literature search identified 56 reports, of which 26 were not included because either the observation period was less than 2 years or the study population was less than 10. Thirty reports remained for data extraction, primarily with the intent to compare the outcome of the zygoma versus conventional implants (Table 8).[58-87]

The studies selected for data extraction were published between 2002[87] and 2014[58-60] and included study participant cohorts that encompassed partially edentate or fully edentulous maxilla. Most of the studies reported that there was general or posterior atrophy, but few described the actual Cawood-Howell classifications.[13] None of the studies included participants with terminal teeth, who received immediate postextraction implants. It was often difficult to judge whether some of the reports described outcomes of the same or separate study participant cohorts.

Between 1990[85] and 2013[60], 1359 study participants received 6394 conventional and zygoma implants. The study settings were single private (n=15), university (n=6), not reported (n=4), public (n=4) or multicenter (n=1). The study cohorts ranged between 11 and 352[61] participants with 48 to 1542[61] implants, followed from two up to 10 years. The implant system used was almost universally manufactured by Nobel Biocare (n=30). Other systems were Defcon (n=1), Phibo (n=1) and one report did not describe the name of the implant manufacturer. Separate outcomes as a function of implant features, e.g., turned versus oxidized implant surface, were not presented in any of the reports.

Studies reporting the effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 6)

The literature search identified 13 reports, of which 9 were subjected for data extraction, primarily with the intent to compare the outcome of the pterygomaxillary versus the conventional implants (Table 9).[88-96]

The studies selected for data extraction were published between 1999[96] and 2013[88] and included study participant cohorts that encompassed partially edentate or fully edentulous maxilla. Most of the studies reported that there was general or posterior atrophy. Two studies included participants with terminal teeth[89,95] who received immediate postextraction implants. It was often difficult to judge whether some of the reports described outcomes of the same or separate study participant cohorts.

A total of 1814 study participants received 6808 implants between 1985[89,90] and 2010. [89,90] The study settings were a single private practice in USA (n=4), or from a single university in Spain (n=4) and one private practice. The study cohorts ranged between 18 and 981[89] participants with 117 to 1817[96] implants, followed from two up to 25 years.[89] The implant systems were manufactured by Nobel Biocare (n=5), Defcon (n=2) and one each by Astra Tech, Biomet 3i, Phibo and Straumann. Four studies reported outcomes as a function of implant design.[89,90,95,96]

Studies designed to report effects of bone augmentation with simultaneous or delayed implant placement reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 7)

The literature search identified 165 reports, of which 92 were not included because either the observation period was less than 2 years or the study population was less than 10. Fifty-five of the 57 excluded papers did not report outcomes as a function of implant design aspects specific to a rehabilitated edentulous maxilla. Sixteen reports remained for data extraction (Table 10).[97-112]

The studies selected for data extraction were published between 1994[112] and 2013[97,98] and included study participant cohorts that encompassed all categories of study participant situations, or included only participants with a fully edentulous maxilla. Most papers described the study participants' atrophic maxilla according to

the Cawood-Howell classification.[13] None of the studies included participants with terminal teeth, who received immediate postextraction implants. It was often difficult to judge whether some of the reports described outcomes of the same or separate study participant cohorts.

A total of 937 study participants received 5667 implants between 1984[105,106,112] and 2009.[97] The study settings were public hospitals (n=8), university (n=5) or multicenter (n=3). The study cohorts ranged between 10 and 224[97] participants with 60 to 1120[102] implants, followed from two up to 14 years.[97] The implant systems were manufactured by Nobel Biocare (n=11), Astra Tech (n=2), Friatec/Friadent (n=1) and Straumann (n=1). One report did not describe the name of the implant manufacturer and another listed four systems with no further details about performance of each.

Studies designed with no *a priori* stated objective to assess a particular implant design feature.[113-122]

We identified these reports amongst the remaining 522 reports, of which 253 were not included because either the observation period was less than 2 years or the study population was less than 10. Two-hundred and fifty-two of the 259 excluded papers did not report outcomes as a function of implant design aspects specific to a rehabilitated edentulous maxilla. Ten reports remained for data extraction (Table 11).[113-122]

The studies selected for data extraction were published between 1994[122] and 2011,[113] and included study participant cohorts that encompassed participants with an edentulous maxilla. Two studies[113,114] included study participants with an atrophic maxilla described according to the Lekholm and Zarb bone classification system.[129] None of the studies included participants with terminal teeth, who received immediate postextraction implants. The three papers co-authored by Jemt et al.[113,115,121] reported from the same study participant cohort in combinations with other cohorts.

In total, 795 study participants received 4382 implants between 1985[121,122] and 2004.[113,117] The study settings were public health clinic (n=5), not reported (n=3), private practice (n=1) or multicenter (n=1). The study cohorts ranged between 25 and 165[113] participants with 59 to 1120 implants,[113] followed from two up to 15 years.[115] The implant systems were manufactured by Nobel Biocare (n=6), Calcitek (n=1),

Biomet 3i (n=1) and Straumann (n=1). One report listed six systems with no further details about performance of each.

Risk of bias within studies

The scientific quality as well as risk of potential bias of the included studies varied considerable. In this systematic review, the risk of bias was trichotomized roughly as high, medium or low. The reader should consider these labels relative only within this review, and they are not comparable to stricter criteria used in other reviews, e.g., Cochrane SRs.

Studies designed with an objective to assess effects of implant design (/-feature) on outcomes (Figure 3.) [18-34]

Two studies were designed as RCTs,[21,32] four as a prospective study with concurrent controls,[22,31,33,34] and 11 as retrospective case series, including one comparing the outcomes with a historical cohort (Table 12). Six of the 17 studies reported approval of an ethics committee.[19,20,23,27,30,31,32,34] Funding was declared in 4 reports.[21,22,30,32] The reported statistics were predominantly some form of time-to-event univariate statistical test, e.g., Kaplan-Meier or actuarial life table, occasionally supplemented with a multivariate test, e.g., linear mixed models or Cox regression tests. The risk of bias varied from low (n=1),[21] medium (n=9) [19,20,23,27,30-34] to high (n=7).

Studies reporting the effects of tilted implants to enable placement of longer implants (Figure 4) [35-57]

One study was designed as an RCT, but the comparison arms were not focused on implant design features. All other papers were prospective (n=12) or retrospective (n=10) case series (Table 13). Eight papers described an approval of from an ethics committee, although only five were listed with name and number.[36,39-42,44,48,52] Study funding was declared in 3 reports.[41,51,55] The reported statistics were predominantly simple parametric or non-parametric statistical hypothesis tests comparing the axial versus the tilted implants (n=7) with or without additional some form of time-to-event univariate statistical test, e.g., Kaplan-Meier or actuarial life table. Two studies described the use of a multivariate test.[37,48] The risk of bias was considered either medium (n=5)[36,37,41,43,48] or high (n=18).

Studies reporting the effects of implants placed in zygomatic bone with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 5).[58-87]

All studies were prospective (n=10) or retrospective (n=22) case series (Table 14). The reported statistics was purely descriptive (n=13), of which four reported 100% survival of the zygoma implants, statistical hypothesis tests (n=3) and/or some form of time-to-event univariate statistical test, e.g., Kaplan-Meier or actuarial life table. No studies described the use of a multivariate test. Only 7 of the 30 papers described an approval from an ethics committee,[59-64,74] and three studies described the source of funding.[70,74,75,86] The risk of bias was considered either medium (n=1)[59] or high (n=29).

Studies reporting the effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 6) [88-96]

All studies were retrospective case series (n=9) (Table 15). The reported statistics was either descriptive (n=5), statistical hypothesis tests (n=2) and/or a time-to-event univariate statistical test (n=4). No studies described the use of a multivariate test. One paper described an approval from an ethics committee[88] and none the source of funding. The risk of bias was considered high for all the studies.

Studies designed to report effects of bone augmentation with simultaneous or delayed implant placement reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 7).[97-112]

Three studies were designed as comparative prospective studies.[98,101,103] One of these focused on comparing block versus particulate bone augmentation, rather than implant design features.[98] The two other studies compared implant designs, but in succession, which risk introducing bias.[101,103] The remaining studies were prospective (n=2) or retrospective (n=9) case series (Table 16). The reported statistics were predominantly descriptive (n=7), statistical hypothesis tests (n=4) and/or some form of time-to-event univariate statistical test, e.g., Kaplan-Meier or actuarial life table (n=6). Four reports applied a multivariate statistical test for data analysis.[97,99,104,111] Only one paper described an approval from an ethics committee, vaguely to the “Local Research Ethics committee”.[99] None of the reports described a

source of funding of the study. The risk of bias was considered either medium (n=3)[99,104,111] or high (n=13).

Studies designed with no *a priori* stated objective to assess a particular implant design feature.[113-122]

The studies were prospective (n=3) or retrospective (n=7) case series (Table 17). The reported statistics were predominantly descriptive (n=2), statistical hypothesis tests (n=3) and/or some form of time-to-event univariate statistical test, e.g., Kaplan-Meier or actuarial life table (n=7). Three studies described the use of a multivariate test.[116,121,122] None of the studies described an approval from an ethics committee. Three reports described a source of funding of the study.[118,120,121] The risk of bias was considered high for all studies.

Results of individual studies

Studies designed with an objective to assess effects of implant design (/-feature) on outcomes (Figure 3).[18-34]

Only one of the 17 papers reported patient-centered outcomes (Table 18). The prevailing reported outcome was incidence of adverse biological and technical events, clinical success or survival and degree of bone loss. Radiographic techniques varied from standardized periapical radiographs to non-standardized orthopanthograms. Some studies reported also indices of periodontal tissues, secondary stability using Resonance Frequency Analysis (RFA) technology or Perio-tester values. Based on the surrogate and clinical outcomes, it can be proposed that in the fully edentulous maxilla the choice of implant system does not appear to influence outcome (n=8 reports). Moreover, the surface may influence outcome (n=4 reports); the length appear not to influence outcome (n=7 reports). As to diameter, wide implants may appear to perform less well (n=2 reports) or comparable to regular diameter implants (n=4 reports). There was extensive variation with regard to healing period following extraction, surgery procedures, and healing period before loading of placed implants, number of implants to support the supraconstruction and the composition and design of the supraconstruction. We considered meta-analyses of the extracted data as inappropriate and abandoned therefore further statistical analyses of the extracted data.

Studies reporting the effects of tilted implants to enable placement of longer implants (figure 4). [35-57]

A relative high proportion of the clinical studies (13 of 23) reported patient-centered outcomes, using a Likert-type scale, dichotomous or a VAS scale (Table 19), although these were about the treatment in general and none were pertinent to issues about implant length. The prevailing reported outcome was incidence of adverse biological and technical events, clinical success or survival and degree of bone loss. Radiographic techniques varied from standardized periapical radiographs to non-standardized orthopanthograms. Some studies reported also indices of periodontal tissues. Based on the surrogate and clinical outcomes, it can be proposed that the clinical performance of axial and tilted implants in the fully edentulous maxilla appear comparable. Moreover, different design from the same manufacturer does not appear to influence outcome, or this was simply not reported when more than one implant design was used. There was extensive variation with regard to healing period following extraction, surgery procedures, and healing period before loading of placed implants, number of implants to support the supraconstruction and the composition and design of the supraconstruction. Formal meta-analyses can be performed for comparing tilted versus axial implants, and has been published elsewhere (Table 2a).

Studies reporting the effects of implants placed in zygomatic bone with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 5) [58-87]

Two studies reported quality of life data using the OHIP-scale,[59,63] while four more described other patient-centered outcomes (Table 20).[76,79-81] Questions about study participant satisfaction did not pertain to implant design effects, but rather to the general treatment outcomes. The prevailing reported outcome was incidence of adverse biological events during or immediately following surgery, and implant survival. The degree of bone loss is seldom reported; basically because there are no radiographic techniques that can adequately depict such loss. Non-standardized orthopanthograms, cbCTs and conventional radiographs using Waters' projection have been attempted. Some studies reported also indices of periodontal tissues and secondary stability using RFA technology. A wide variation was observed with regard to healing period following extraction, surgery procedures, and healing period before

loading of placed implants, number of implants to support the supraconstruction and the composition and design of the supraconstruction.

Appraising the potential effects of the implant design on outcomes when pertaining to zygoma implants is complex, because of inadequate descriptions of the implant brand. For a start, the company Brånemark Integration AB. manufactured for a period a product named “Z-fixture”, which many have confused with a product named “Brånemark system zygoma implant” manufactured by Nobel Biocare. One early generation of the zygoma implants included a cervical hole meant for the abutment screw that potentially could allow direct communication from the oral cavity to the sinus if the abutment screw did not completely obliterate the canal. The second generation of such implants contained no such holes. The 3rd generation avoids threads in the coronal 1/3 of the implant, while the 4th generation incorporates engaging threads and a narrow apical tip. So far, no studies have compared any of these designs one to one. A few studies that included both turned and oxidized zygoma implants did not describe whether there were differences in outcomes between the two.[62,66,72,74,75,82]

When appraising the possible effects of zygoma implant design on outcomes it is important to be aware that at least four different surgical techniques have been described and one implant design used for one technique may not be optimal for another. The original protocol described a transinus placement.[86] An alternative extrasinus approach could be used when large buccal concavity in the sinus area otherwise would displace the zygoma implant head very far palatinally.[68] A third approach named the sinus slot technique creates a different angulation of the zygoma implant that places the implant head on the top of the alveolar crest while avoiding penetrating the sinus schneiderian membrane.[73] The last alternative is to anchor the implant solely in the zygomatic bone and remaining mostly outside of the maxilla.[64]

Studies reporting the effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 6). [88-96]

One study reported quality of life data using the OHIP-14 scale,[88] while two more described other patient-centered outcome (Table 21).[93,94] The prevailing reported outcome was incidence of adverse biological and technical events, clinical success or

survival and degree of bone loss, based on orthopantograms. Based on the surrogate and clinical outcomes, it appears that the clinical performance of implants placed in bony buttresses in the fully edentulous maxilla as well as in the pterygomaxillary bone, appear comparable. Several reports that describe implant placements in the pteromaxillary bone combine these with zygoma implants (Table 20). One investigator center has reported that different designs from the same manufacturer may not influence outcome (n=2),[95,96] in contrast to influence of the surface (n=1)[90] and the implant length (n=1).[89] There was extensive variation with regard to healing period following extraction, surgery procedures, and healing period before loading of placed implants, number of implants to support the supraconstruction and the composition and design of the supraconstruction. We considered meta-analyses of the extracted data as inappropriate and abandoned therefore further statistical analyses of the extracted data.

Studies designed to report effects of bone augmentation with simultaneous or delayed implant placement reporting an effect of a particular implant design feature on one or more treatment outcomes (figure 7). [97-112]

Two of the 16 clinical studies reported patient-centered outcomes (Table 22).[100,101] The prevailing reported outcome was incidence of adverse biological events during or immediately following surgery, late adverse biological and technical events, clinical success or survival and degree of bone loss. Some studies reported also indices of periodontal tissues. Based on the surrogate and clinical outcomes, it can be proposed that in the fully edentulous maxilla the choice of implant system may not (n=2) influence outcome.[97,108] Two studies reported differences between implant designs, but both compared implant system A during a learning curve, versus design B afterwards.[101,103] Moreover, different design from the same manufacturer may influence outcome (n=1),[105] while the length may (n=8) or may not (n=3) influence outcome. There was extensive variation with regard to healing period following extraction, surgery procedures, and healing period before loading of placed implants, number of implants to support the supraconstruction and the composition and design of the supraconstruction. We considered meta-analyses of the extracted data as inappropriate and abandoned therefore further statistical analyses of the extracted data. The conclusions about effect of implant length on outcome were all from studies

applying a one-stage approach with extensive grafting and implants placed to stabilize the graft (n=8).[102,104,106,107,109-112] The three studies that found no such effect applied a two-stage approach, with a four to eight months healing period in-between.[98,99,100]

Studies designed with no *a priori* stated objective to assess a particular implant design feature.[113-122]

None of the nine clinical studies reported patient-centered outcomes (Table 23). The prevailing reported outcome was incidence of adverse biological and technical events, clinical success or survival and degree of bone loss, measured on peri-apical radiographs. Based on the surrogate and clinical outcomes, it can be proposed that in the fully edentulous maxilla the choice of implant system appear to influence outcome (n=1).[118] Moreover, different designs from the same manufacturer does not change outcome (n=1), the surface may not influence outcome (n=1)[113] wide (n=1)[120] and short implants may (n=5)[114,115,119,121,122] or may not (n=2)[116,117] influence outcomes. There was extensive variation with regard to healing period following extraction, surgery procedures, and healing period before loading of placed implants, number of implants to support the supraconstruction and the composition and design of the supraconstruction. We considered meta-analyses of the extracted data as inappropriate and abandoned therefore further statistical analyses of the extracted data.

Discussion

Summary of the evidence

Arguably, we have identified far more clinical studies aimed to appraise possible effects of implant design on outcomes in the fully edentulous maxilla in comparison with other systematic reviews (Table 2a, b). Unfortunately, the great majority of the primary reports aimed to appraise possible effects of implant design on outcomes lump their observed data, probably with the objective to obtain more statistical power. The consequence is that the readers cannot judge outcomes specifically related to the various clinical conditions, such as for the fully edentulous maxilla. Moreover, many reports present inadequate statistics generally associated with incorrect choice of statistical unit.[123-125] Multivariable linear or logistic regression models were

occasionally applied in the reports, but often with clear violations of statistical assumptions generally associated with multiple within-subject factors.[126-128]

The general impression of the available evidence is that there is a lack of compelling data to state that one particular implant system or design feature stands out amidst others, when applied to restoring the fully edentulous maxilla with implant-retained prosthetics.

Limitations at the study and outcome level

Characteristics of the study groups and participant inclusion and exclusion criteria

Although the term “edentulous maxilla” is easy to understand, it is more difficult to categorize into groups based on difficulties of rehabilitating facial form and oral functions. There are multiple variants and codification sets of the edentulous maxilla. The most well known is a classification system developed by the American College of Prosthodontics (ACP), [2] which emphasizes the restoration of form and function with conventional dentures in patients with increasing complexity depending on specific general and local elements. Several systems for describing jaw size and consistency have also been proposed in the implant literature.[13,129-131] Further attempts to evaluate the risks associated with implant treatment have resulted in the SAC classification system (Straightforward-Advanced-Complex), developed by the International Team for Implantology (www.iti.org). The difficulties with the use of these classifications are to identify which of the many criteria used are prognostic factors for the treatment outcome, since these criteria are not necessarily risk factors.

Although not presented in this SR, a vast spectrum of study inclusion and exclusion criteria were identified. The most common inclusion and exclusion criteria were (i) Participant level: Age – maximum or minimum, general health condition, past drug or alcohol abuse, extent of smoking, bruxism or clenching history, past radiation therapy, compliance and commitment to follow-up; (ii) Intra-oral condition: state of edentulousness, adequate bone height and width, bone quality, maxillomandibular discrepancy or lack of vertical space, no local pathology, no sinus inflammation, level of oral hygiene, healed alveolar ridge, augmentation or grafting; (iii) Surgical: minimum primary stability, minimum keratinized mucosa. While most papers described a few or multiple criteria, it is likely that many reports have under-reported the range of criteria. It is therefore uncertain how the potential effects of implant

design on outcomes in the fully edentulous maxilla should be interpreted in light of the described, or lack of described inclusion and exclusion criteria.

Description of the intervention

The surgical protocols may significantly affect outcomes of studies comparing implant design aspects and therefore, protocols need to be appraised in context with our data interpretation. Similarly, different settings and operators with different levels of skills and experience will probably influence outcomes of studies comparing implant design aspects. Particularly, there are reports showing that the level of surgical experience may influence the failure percentage of implants.[132,133] While some articles report these details, most do not.

In this regard, it is essential to consider the years when implants were placed and be reminded of the surgical principles at the time. Investigators designing studies in the eighties were prone to the rather strict principle that implant parallelism was essential, which trumped implant angulation even in the presence of bone. Another argument was that costs would increase significantly, because angulated abutments would be required.[113] At the time, the clinician would strive to place a parallel, say 7 mm implant with a turned surface. Today, a clinician would have no qualms angulating the implant to increase implant length beyond 7mm in most any direction. Comparing incidences of adverse outcomes in contemporary studies with historical data applying different SOPs is therefore fraught with interpretational fallacies. It was not until around the turn of the century data emerged that placing non-axial loaded implants were not necessarily detrimental to the patient.[56, 57] Subsequently, these concepts led to surgical protocols based on the use of 2 or 4 axial plus 2 tilted implant solutions. High quality long-term studies of the concept are hopefully underway.

Studies that include grafting procedures in connection with implant placement may increase the risk of adverse outcomes irrespective from the implant design. The same applies to immediate placement following tooth extraction, and perhaps even the reason for extraction may have some bearing on the osseointegration process. Other clinical variables that come into play are the time of loading of the implants; implant bed preparation protocol and/or primary stability. In fact, most studies reviewed did not have a description about implant stability.

The number of implants to support a supraconstruction, as well as the material composition and design of the supraconstruction itself probably influence the treatment outcomes in studies aimed to compare implant design aspects. Currently, however, there are no published study findings that can provide for clinical guidance.

Some investigators and authors of systematic reviews have suggested that implant length and diameters has an effect of outcomes. This may or may not be correct when applied to single implants and perhaps small fixed dental prostheses. However, unless planned a priori in a study protocol, it is more likely that a narrow, wide, and/or short implant placed amongst “standard” size implants to support a full jaw suprastructure is a reflection of an unfavorable site for osteotomy. It follows that reported higher failure rates of these narrow or wide and/or short implants is not a reflection of the effects of the implant design on outcomes, but rather from the effects of unfavorable local anatomical conditions.[6]

With regard to the implant surface, we may be faced with a new dimension of scientific rationale and technological strategies based on novel approaches to enhance the biological process of osseointegration.[10] A focus of implant surface design and science has been its morphology or topography, as extensively documented in the studies comparing machined/turned surfaces and so-called rough surfaces. In fact, many studies reviewed in this paper compared implants from different manufactures, presumably having different surface morphology. Recently, studies have uncovered the significant role of physicochemical property of titanium surfaces in determining their biological capabilities.[134-136] Physicochemical property includes hydrophilicity or hydrophobicity, the degree of hydrocarbon contamination, and electrostatic status. More importantly, these properties change with time in an unfavorable way, as evidenced in the phenomenon that newly prepared titanium surfaces are hydrophilic, whereas the same titanium surfaces stored for a certain time are hydrophobic.[137] The degraded physicochemical properties may be restored by, e.g., ultraviolet light treatment immediately prior to use or by photofunctionalization.[134, 138] Photofunctionalization is not categorized as neither additive nor subtractive modification. It simply removes hydrocarbons from the implant surface and regenerates hydrophilicity. The process, termed surface conditioning, is theoretically universal for any titanium- and titanium alloy-based implant materials, which may affect how we think of the implant design and suggest

necessity to broaden our scope. These innovative implant surfaces have not yet been evaluated clinically in patients with a fully edentulous maxilla.

Reported outcomes following clinical studies should ideally be patient-centered. The majority of clinical studies, however, report implant survival data and some also include periimplant bone loss and advent of adverse biological events, but seldom patient-centered outcomes or other variables related with treatment morbidity.

Very few studies reported outcomes comparing different implant types or particular design features, at least pertaining to patients with a fully edentulous maxilla. One important issue in implant research is that most of clinical studies are financed by industry and hence, they are mostly case series or comparing implants systems from the same manufacturer. This possible bias related to the conflict of interest when reporting negative results may have probably prevented the publication of many conducted, but unpublished investigations. Moreover, as stated earlier, very few studies reported patient-centered outcomes.

Limitations at the review-level

The Academy of Osseointegration determined *a priori* this very broad and general PICO question, what indicates that it is likely that other investigators aiming to replicate this SR will possibly identify different studies and organize the extracted data in a different manner, perhaps even leading to different conclusions. Moreover, the review of such broad subject prevents the answer to a predefined null-hypothesis, and instead leads to a narrative description of a vast number of different studies, which prevent the appropriate data extraction and meta-analysis.

The online bibliographic searches identified in sum less than half of the total number of relevant clinical studies (Figure 2). This moderate yield may appear surprising, but others have claimed that online searches identify only 20 – 40% of relevant studies, regardless of expert search algorithms.[139,140] Hence, hand-searching of reference lists in identified reports is always required, and the process is greatly facilitated if further combined with the use of hyperlinked online reference listed, e.g., the online Web of Science. Nevertheless, in this review a substantial number of the identified reports were uncovered in a personal indexed database managed by the lead author since the mid-eighties and used in systematic reviews previously.[141]

Conclusions

This systematic review failed to identify compelling evidence to conclude that any particular implant or feature affects the outcome of the treatment of patients with a fully edentulous maxilla. This conclusion is in line with the previous and recently updated Cochrane systematic review focused on the identical topic.[142] The difference between the current SR and the Cochrane review is that the latter reviewed only randomized clinical trials. On the other hand, the Cochrane review appraised effects in meta-analyses that merged data from a range of different clinical conditions, including single space and partially edentate situations in both jaws. In contrast, the current review appraise outcomes only in study participants with a fully edentulous maxilla.

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Legends to figures

Figure 1. Illustration of approximate remaining maxillary bone according to the Cawood-Howell bone classification system.[13] Note that the authors did not state the dimensions in millimetres in their original paper.

Figure 2. PRISMA flow-chart.[12] Reports on implant supported prosthesis, in fully edentulous maxilla.

Figure 3. Examples of variations in study designs applied to appraise effects of implant design features, beyond parallel study cohort comparisons.[21] Top, placement of implants in random locations, in this case Brånemark implants with two different tap relief profiles.[34] Middle, split-mouth study, e.g., comparing effects of different CoreVent implants.[32] Bottom, comparing short Straumann implants placed in limited bone distally, with longer implants placed anteriorly in study participants with Cawood-Howell class IV maxilla.[22]

Figure 4. Examples of diversity of surgical approaches using tilted implants. Two top examples were alternatives to bone augmentation techniques in study participants with Cawood-Howell (C-H) bone class II to VI.[56, 57] Top left show four distally tilted Brånemark implants in a C-H V/VI maxilla,[57] central left two axial and two 30-45° distally tilted Brånemark implants in C-H III/IV maxilla,[55] bottom left two axial and two 30° distally tilted "externally hexed" implants in immediate extraction sockets (C-H II).[44] Note relative gain in tilted implant lengths versus axial as a function of increasing bone height. Right figures show alternatives to bone augmentation techniques in study participants with C-H V/VI bone, top two distally+four mesially 25-30° tilted + two Brånemark implants in palatal vault,[56] central two axial + four 25-30° mesially and distally tilted Brånemark implants[52] and bottom, two axial and two distally tilted implants, but through the sinus to obtain fixation in four layers of cortical bone.[39]

Figure 5. Examples of diversity of surgical approaches using zygomatic implants in study participants with Cawood-Howell bone class IV to VI. Top left shows two trans-sinus zygomatic plus e.g., two conventional implants,[87] bottom left four trans-sinus zygomatic,[86] top right two extra-sinus zygomatic plus, e.g., four conventional implants,[64] bottom right four extra-sinus zygomatic implants.[68]

Figure 6. Examples of use of pterygomaxillary implants in study participants with Cawood-Howell bone class IV to VI. Top, two Brånemark pterygomaxillary plus six conventional

Brånemark implants,[96] bottom, two Brånemark pterygomaxillary plus six Brånemark conventional implants plus two zygomatic implants, AKA “teeth-in-an-hour” concept.[95]

Figure 7. Examples of diversity of surgical approaches for bone augmentation with simultaneous or delayed implant placement in study participants with Cawood-Howell bone class IV to VI. Top, left, LeFort 1 Fracture with interpositional fixation and immediate or delayed placement of e.g., 6 Brånemark implants.[109] Middle, left full-arch onlay block with e.g., 6 immediate Brånemark implants.[104] Bottom, left, segmental block onlay with delayed Brånemark implants. Top, right, segmental inlay blocks in sinus with six immediate loading Brånemark implants,[112] Middle, right segmental inlay blocks in sinuses and nasally with e.g., nine immediate loading Brånemark implants,[106] Bottom, right, segmental blocks in sinus plus horizontal onlay anteriorly with Brånemark implants placed 4 to 7 months later.[102]

Table 1. Search strategy for MEDLINE through Pubmed adopted from a recent systematic review on the prosthetic rehabilitation of patients with edentulous jaws, conducted by the Swedish Council on Health Technology Assessment.[11]

("Dental Implants"[Mesh:noexp] OR "Dental Implantation, Endosseous"[Mesh:noexp] OR "Blade Implantation"[Mesh] OR (("Dentistry"[Mesh] OR "dental"[Title/Abstract])

AND

("Osseointegration"[Mesh] OR "osseointegration"[Title/Abstract])) OR ("dental"[Title/Abstract]

AND

("implant"[Title/Abstract] OR "implants"[Title/Abstract] OR "implantation"[Title/Abstract])))

AND

("Denture, Overlay"[Mesh] OR "Denture, Complete"[Mesh] OR "Denture, Partial, Removable"[Mesh] OR "Dental Prosthesis, Implant-Supported"[Mesh] OR "Denture, Fixed"[Mesh:noexp] OR "denture"[Title/Abstract] OR "prosthesis"[Title/Abstract])

AND

("edentulous"[Title/Abstract] OR "Jaw, Edentulous"[Mesh:noexp] OR "Mouth, Edentulous"[Mesh:noexp] OR "edentulism"[Title/Abstract]) NOT "partially edentulous"[Title/Abstract]

AND

"Maxilla" [MeSH]

Table 2a. Systematic reviews with focus on rehabilitation of the fully edentulous maxilla applying different surgical strategies, or with focus on assessing the patient-relevant outcomes, published since 2009.

Lead author	Title	Source	Aim
Bassi et al. (2013)	Economic outcomes in prosthodontics.	Int J Prosthodont 2013; 26: 465-469	To identify the types of economic measures currently used in implant prosthodontics and determine the degree to which cost of care is considered in the context of any positive outcome of the care provided
Bassi et al. (2013)	Functional outcomes for clinical evaluation of implant restorations.	Int J Prosthodont 2013; 26: 411-418	To identify functional assessments of speech, swallowing, mastication, nutrition, sensation, and motor function as they relate to dental implant therapies
Bassi et al. (2013)	Psychologic outcomes in implant prosthodontics.	Int J Prosthodont 2013; 26: 429-434	To identify psychologic outcomes with properties deemed critical to meet clinical trial and clinical practice needs for the future
Bidra & Huynh-Ba (2011)	Implants in the pterygoid region: a systematic review of the literature.	Int J Oral Maxillofac Surg 2011; 40: 773-81	To identify clinical studies on the short-term and long-term survival of implants placed in the pterygoid region
Bozini et al. (2011)	A meta-analysis of prosthodontic complication rates of implant-supported fixed dental prostheses in edentulous patients after an observation period of at least 5 years	Int J Oral Maxillofac Implants 2011; 26: 304-318	To systematically review clinical studies on prosthodontic complication rates of implant fixed dental prostheses in edentulous patients after an observation period of at least 5 years
Cehreli et al (2010)	A systematic review of marginal bone loss around implants retaining or supporting overdentures.	Int J Oral Maxillofac Implants 2010; 25: 266-277	To evaluate, through a systematic review of the literature, the effects of implant design and attachment type on marginal bone loss in implant-retained/supported overdentures.
Cehreli et al. (2010)	Systematic review of prosthetic maintenance requirements for implant-supported overdentures.	Int J Oral Maxillofac Implants 2010; 25: 163-80	To evaluate prosthetic maintenance requirements for implant-retained/supported overdentures via a review of the literature.
Chrcanovic & Abreu (2012)	Survival and complications of zygomatic implants: a systematic review.	Oral Maxillofac Surg 2013; 17: 81-93 [Epub 2012]	To answer the focused questions: "What is the survival rate of zygomatic implants (zis)?" and "What are the most common complications related to surgery of zygomatic implants?"
Chung et al. (2011)	Immediate loading in the maxillary arch: evidence-based guidelines to improve success rates: a review.	J Oral Implantol 2011; 37: 610-621.	Investigates the status of immediate loading of dental implants in the maxilla to determine its predictability as a treatment option for partial and complete maxillary edentulism
Corbella et al. (2013)	Long-Term Outcomes for the Treatment of Atrophic Posterior Maxilla: A Systematic Review of Literature.	Clin Implant Dent Relat Res 2014; 16: [Epub 2013]	To estimate the implant survival rate in different types of techniques for the rehabilitation of posterior atrophic maxilla, after at least 3 years of follow-up.
Del Fabbro & Ceresoli	The fate of marginal bone around axial vs. tilted implants: A systematic review.	Eur J Oral Implantol 2014; 7: 171-	To compare the crestal bone level change around axially placed vs. Tilted implants supporting fixed prosthetic reconstructions for the rehabilitation of

Lead author	Title	Source	Aim
(2014)		189	partially and fully edentulous jaws, after at least 1 year of function.
Del Fabbro et al. (2012-201e)	Tilted implants for the rehabilitation of edentulous jaws: a systematic review.	Clin Implant Dent Relat Res 2012; 14: 612-621 [Epub 2010]	To evaluate the survival rate of upright and tilted implants supporting fixed prosthetic reconstructions for the immediate rehabilitation of partially and fully edentulous jaws, after at least 1 year of function.
Dellavia et al. (2014)	Functional jaw muscle assessment in patients with a full fixed prosthesis on a limited number of implants: A review of the literature.	Eur J Oral Implantol 2014; 7: 155-169	To assess the function of jaw muscles in edentulous patients restored with full fixed prostheses on a limited number (≤ 6) of implants, as compared to dentate subjects and edentulous subjects wearing dentures, implant-supported overdentures or full fixed prostheses supported by more than six implants.
Esposito & Worthington (2013)	Interventions for replacing missing teeth: dental implants in zygomatic bone for the rehabilitation of the severely deficient edentulous maxilla.	Cochrane Database Syst Rev CD004151 2013(p3) Update of: 2005(p2), 2003(p1)	To test the hypothesis of no difference in outcomes between zygomatic implants without bone augmenting procedures in comparison with conventional dental implants in augmented bone for severely resorbed maxillae
Esposito et al. (2014)	Interventions for replacing missing teeth: augmentation procedures for the maxillary sinus	Cochrane Database Syst Rev CD008397 2014(p2) Update of: 2010(p1)	To determine whether and when augmentation of the maxillary sinus are necessary and which are the most effective augmentation techniques for rehabilitating patients with implant-supported prostheses
Gallucci et al. (2009)	Loading protocols for dental implants in edentulous patients	Int J Oral Maxillofac Implants 2009; 24 Suppl: 132-146	[ITI4] to present the current scientific and clinical evidence related to implant-supported rehabilitations for the edentulous mandible and maxilla.
Goiato et al. (2014)	Implants in the zygomatic bone for maxillary prosthetic rehabilitation: a systematic review	Int J Oral Maxillofac Surg 2014; 43: 748-757	To evaluate clinical studies on the follow-up survival of implants inserted in the zygomatic bone for maxillary rehabilitation.
Heydecke et al. (2012)	What is the optimal number of implants for fixed reconstructions: a systematic review.	Clin Oral Implants Res 2012; 23 Suppl 6: 217-228	To assess the 5-year and 10-year survival and complication rates of implant-supported fixed reconstructions in partially and totally edentulous patients with regard to the optimal number and distribution of dental implant
Kotsakis et al. (2014)	A Systematic Review of Observational Studies Evaluating Implant Placement in the Maxillary Jaws of Medically Compromised Patients	Clin Implant Dent Relat Res 2014; 16: [Epub ¨2014]	To evaluate the survival of implants placed in the maxillary jaws of medically compromised patients.
Lambert et al. (2009)	Descriptive analysis of implant and prosthodontic survival rates with fixed implant-supported rehabilitations in the edentulous maxilla.	J Periodontol 2009; 80: 1220-1230	To reviewed the 1- to 15-year survival rates of fixed implant rehabilitations in the edentulous maxilla.
McGrath et al.	An evidence-based review of patient-reported outcome	J Clin Periodontol	To conduct an EB review of patient-reported outcome measures in dental implant research among dentate

Lead author	Title	Source	Aim
(2012)	measures in dental implant research among dentate subjects	2012; 39: 193-201	patients so as to gain an understanding of the use of such measures, and the potential evidence that can be gleaned from such studies
Menini et al. (2012)	Tilted implants in the immediate loading rehabilitation of the maxilla: a systematic review.	J Dent Res 2012; 91: 821-827	To evaluate the outcomes of upright and tilted implants supporting full-arch fixed dentures for the immediate rehabilitation of edentulous maxillae, after at least 1 year of function
Mericske-Stern & Worni (2014)	Optimal number of oral implants for fixed reconstructions: A review of the literature.	Eur J Oral Implantol 2014; 7: 133-153	To review best evidence for the preferred or best number of implants to be used for the support of a fixed prosthesis in the edentulous maxilla or mandible,
Monje et al. (2012)	Marginal bone loss around tilted implants in comparison to straight implants: a meta-analysis.	Int J Oral Maxillofac Implants 2012; 27: 1576-1583	To compare the amount of marginal bone loss around tilted and straight implants. As the secondary aim, the incidence of biomechanic complications was compared.
Ohkubo & Baek (2010)	Does the presence of antagonist remaining teeth affect implant overdenture success? A systematic review.	J Oral Rehabil 2010; 37: 306-312	To clarify the correlation between existing remaining teeth and the survival/success rate of maxillary and mandibular implant overdentures
Papaspyridakos et al. (2012)	A systematic review of biologic and technical complications with fixed implant rehabilitations for edentulous patients	Int J Oral Maxillofac Implants 2012; 27: 102-110	To assess the incidence and types of biologic and technical complications associated with implant-supported fixed complete dental prostheses (ifcdps) for edentulous patients.
Patzelt et al. (2013e)	The All-on-Four Treatment Concept: A Systematic Review.	Clin Implant Dent Relat Res 2014; 16: [Epub 2013]	To evaluate the all-on-four treatment concept with regard to survival rates (srs) of oral implants, applied fixed dental prostheses (fdps) and temporal changes in proximal bone levels.
Pommer et al. (2014)	Patients' preferences towards minimally invasive treatment alternatives for implant rehabilitation of edentulous jaws.	Eur J Oral Implantol 2014; 7: 91-109	To evaluate patient satisfaction, oral health-related quality of life, and patients' preferences towards minimally invasive treatment options for graftless rehabilitation of complete edentulism by means of dental implants.
Raghoebar et al. (2014)	A systematic review of implant-supported overdentures in the edentulous maxilla, compared to the mandible: How many implants?	Eur J Oral Implantol 2014; 7: 191-201	To review the treatment outcome of concepts used for implant-supported maxillary overdentures, focusing on the survival of implants, survival of maxillary overdentures and condition of the implant surrounding hard and soft tissues after a mean observation period of at least 1 year
Roccuzzo et al. (2012)	What is the optimal number of implants for removable reconstructions? A systematic review on implant-supported overdentures.	Clin Oral Implants Res 2012; 23 Suppl 6: 229-237	To assess the optimal number of implants for removable reconstructions
Sánchez-Ayala et al. (2010)	Nutritional effects of implant therapy in edentulous patients--a systematic review.	Implant Dent 2010; 19: 196-207.	To present all the relevant studies that have evaluated the possible physical and nutrient intake improvement of edentulous subjects rehabilitated with removable and supported or retained implant denture
Schley & Wolfart (2011)	Which prosthetic treatment concepts present a reliable evidence-based option for the edentulous maxilla related to number and position of dental	Eur J Oral Implantol 2011; 4: 31-47	To answer the following questions: Which prosthetic treatment concept related to implant number and position presents a reliable evidence-based option for the edentulous maxilla?

Lead author	Title	Source	Aim
	implants?		
Slot et al. (2010)	A systematic review of implant-supported maxillary overdentures after a mean observation period of at least 1 year.	J Clin Periodontol 2010; 37: 98-110	To assess the survival of implants, survival of maxillary overdentures and the condition of surrounding hard and soft tissues after a mean observation period of at least 1 year.
Vogel et al. (2013)	Evaluating the health economic implications and cost-effectiveness of dental implants: a literature review.	Int J Oral Maxillofac Implants 2013; 28: 343-356	To review the available literature on the costs and cost-effectiveness of dental implant-supported or -retained prostheses versus tooth-supported fixed partial denture restorations or mucosa-borne conventional complete or partial dentures

Table 2b. Systematic reviews with focus on effects of characteristics of implant, e.g., material, surface, dimension including diameter or length, one-or-two-piece, implant-abutment connection on outcomes, published since 2009.

Lead author	Title	Source	Aim
Abrahamsson & Berglundh (2009)	Effects of different implant surfaces and designs on marginal bone-level alterations: a review.	Clin Oral Implants Res 2009; 20 Suppl 4: 207-215	To evaluate the effect of different implant surfaces and designs on marginal bone-level (MBL) alterations.
Al-Nsour et al. (2012)	Effect of the platform-switching technique on preservation of peri-implant marginal bone: a systematic review	Int J Oral Maxillofac Implants 2012; 27: 138-145	To systemically review the effect of platform switching on preserving implant marginal bone.
Aloy-Prósper et al. (2011)	Marginal bone loss in relation to the implant neck surface: an update.	Med Oral Patol Oral Cir Bucal 2011; 16: e365-368	To appraise publications on the marginal bone loss of implants with a polished neck, rough neck with microthreading, and rough neck without microthreading
Alsabeeh a et al. (2012)	Hydroxyapatite-coated oral implants: a systematic review and meta-analysis.	Int J Oral Maxillofac Implants 2012; 27: 1123-30	To evaluate treatment outcomes of hydroxyapatite-coated implants in comparison to nonhydroxyapatite-coated implants
Andreiotelli et al. (2009)	Are ceramic implants a viable alternative to titanium implants? A systematic literature review.	Clin Oral Implants Res 2009; 20 Suppl 4: 32-47	To locate animal and clinical data on bone-implant contact (BIC) and clinical survival/success that would help to answer the question 'Are ceramic implants a viable alternative to titanium implants?
Annibali et al. (2011)	Short Dental Implants: A Systematic Review.	J Dent Res 2012; 91: 25-32	To systematically evaluate clinical studies of implants < 10 mm in length, to determine short implant-supported prosthesis success in the atrophic jaw
Annibali et al. (2012)	Peri-implant marginal bone level: a systematic review and meta-analysis of studies comparing platform switching versus conventionally restored implants.	J Clin Periodontol 2012; 39: 1097-1113	To systematically review the literature to compare implant survival (IS) and marginal bone loss (MBL) around platform-switched (PS) versus conventionally restored platform-matching dental implants.
Atieh et al. (2010)	Platform switching for marginal bone preservation around dental implants: a systematic review and meta-analysis.	J Periodontol 2010; 81: 1350-1366	To systematically review radiographic marginal bone-level changes and the survival of platform-switched implants compared to conventional platform-matched implants.
Atieh et al. (2012)	Survival of short dental implants for treatment of posterior partial edentulism: a systematic review.	Int J Oral Maxillofac Implants 2012; 27: 1323-31.	To systematically review studies concerning dental implants of ≤ 8.5 mm placed in the posterior maxilla and/or mandible to support fixed restorations
Barrachina-Diez et al. (2013)	Long-term outcome of one-piece implants. Part I: implant characteristics and loading protocols. A systematic literature review with meta-analysis	Int J Oral Maxillofac Implants 2013; 28: 503-518	To evaluate the long-term clinical performance of one-piece implants.
Barrachina-Díez et al. (2013)	Long-term outcome of one-piece implants. Part II: Prosthetic outcomes. A systematic literature review with meta-analysis.	Int J Oral Maxillofac Implants 2013; 28: 1470-1482	To evaluate the long-term clinical performance of prosthetic reconstructions on one-piece implants, with a focus on technical and biological complications.

Lead author	Title	Source	Aim
Bateli et al. (2011)	Implant neck configurations for preservation of marginal bone level: a systematic review	Int J Oral Maxillofac Implants 2011; 26: 290-303	To evaluate the effectiveness of various implant neck configurations in the preservation of marginal bone level as well as to identify the available scientific evidence.
Bishti et al. (2014-2013e)	Effect of the implant-abutment interface on peri-implant tissues: A systematic review.	Acta Odontol Scand 2014; 72: 13-25 [Epub 2013]	To determine the peri-implant tissue response to different implant abutment materials and designs available and to assess the impact of tissue biotype
Depprich et al. (2014-2012e)	Current Findings Regarding Zirconia Implants	Clin Implant Dent Relat Res 2014;16:124-137. [Epub 2012]	To analyze the available clinical data on the survival and success rate of dental zirconia implants (ZI).
Elangovan et al. (2013)	Quality assessment of systematic reviews on short dental implants.	J Periodontol 2013; 84: 758-767	To analyze the quality of published systematic reviews focused on short dental implants using established checklists such as the assessment of multiple systematic reviews (AMSTAR).
Esposito et al. (2014)	Interventions for replacing missing teeth: different types of dental implants	Cochrane Database Syst Rev CD003815 2014(p4) Update of: 2007(p4) 2005(p3), 2003(p2), 2002(p1)	To test the null hypothesis of no difference in clinical performance between various root-formed osseointegrated dental implant types
Gracis et al. (2012)	Internal vs. external connections for abutments/reconstructions: a systematic review.	Clin Oral Implants Res 2012; 23 Suppl 6: 202-216	To evaluate the accuracy of implant-level impressions in cases with internal and external connection abutments/reconstructions, and (2) to evaluate the incidence of technical complications
Junker et al. (2009)	Effects of implant surface coatings and composition on bone integration: a systematic review.	Clin Oral Implants Res 2009; 20 Suppl 4: 185-206	To evaluate the bone integration efficacy of recently developed and marketed oral implants as well as experimental surface alterations.
Kotsovilis et al. (2009)	A systematic review and meta-analysis on the effect of implant length on the survival of rough-surface dental implants.	J Periodontol 2009; 80: 1700-1718	To address the focused question "Is there a significant difference in survival between short (or=10 mm) rough-surface dental implants placed in 1) totally or 2) partially edentulous patients
Laurell & Lundgren (2011-2009e)	Marginal Bone Level Changes at Dental Implants after 5 Years in Function: A Meta-Analysis	Clin Implant Dent Relat Res 2011; 13: 19-28 [Epub 2009]	To compile and compare data on peri-implant marginal bone level changes from prospective studies that have registered the peri-implant marginal bone level radiographically after 5 years of follow-up for implant systems currently available on the market.
Menchero-Cantalejo et al. (2011)	Meta-analysis on the survival of short implants.	Med Oral Patol Oral Cir Bucal 2011; 16: e546-551	To evaluate the success and failure rates of short implants (10 mm or less) for oral rehabilitations in cases of limited bone height.
Monje et al. (2013a)	Are short dental implants (<10 mm) effective? A meta-analysis on prospective clinical trials.	J Periodontol 2013; 84: 895-904	To compare the survival rate of short (
Monje et al. (2013b)	Do Implant Length and Width Matter for Short Dental Implants (<10 mm)? A Meta-Analysis of Prospective Studies.	J Periodontol 2013; 84: 1783-1791	To determine the effects of dental implant length and width on implant survival rate of short (6-9mm) implants
Neldam & Pinholt	State of the Art of Short Dental Implants: A	Clin Implant Dent Relat Res 2012; 14:	To evaluate publications concerning short dental implants defined as an implant with a length of ≤8

Lead author	Title	Source	Aim
(2012)	Systematic Review of the Literature	622-632	mm installed in the maxilla or in the mandible with special reference to implant type, survival rate, location of implant site, and observation time
Pommer et al. (2011)	Impact of dental implant length on early failure rates: a meta-analysis of observational studies	J Clin Periodontol 2011; 38: 856-863	To test the null hypothesis of no difference in failure rates of short (minimum length: 7 mm) and longer dental implants (≥ 10 mm), a meta-analysis was performed on prospective observational trials.
Renvert et al. (2011)	How do implant surface characteristics influence peri-implant disease?	J Clin Periodontol 2011; 38 Suppl 11: 214-222	To review the literature on how implant surface characteristics influence peri-implant disease.
Romeo et al. (2010)	The use of short dental implants in clinical practice: literature review.	Minerva Stomatol 2010; 59: 23-31	To evaluate the differences in survival rate and the rational use of short implants.
Rungruanganunt et al. (2013)	The effect of static load on dental implant survival: a systematic review.	Int J Oral Maxillofac Implants 2013; 28: 1218-1225	To systematically review the current evidence related to the effects of static loading on the long-term stability of the osseointegrated interface
Schmitt et al. (2013)	Performance of conical abutment (Morse Taper) connection implants: A systematic review	J Biomed Mater Res A 2013 [Epub 2013]	To compare conical versus nonconical implant-abutment connection systems in terms of their in vitro and in vivo performances
Sohrabi et al. (2012)	How successful are small-diameter implants? A literature review	Clin Oral Implants Res 2012; 23: 515-524	To determine (i) the survival of narrow diameter implants, (ii) whether survival is dependent on whether these implants are placed using a flap or flapless approach (iii) whether there is a relationship between length and implant survival in sdis.
Srinivasan et al. (2012)	Efficacy and predictability of short dental implants (<8 mm): a critical appraisal of the recent literature.	Int J Oral Maxillofac Implants 2012; 27: 1429-1437	To evaluate the predictability of treatment outcomes with short dental implants (SDI), ie, implants shorter than 8 mm.
Srinivasan et al. (2013)	Survival rates of short (6 mm) micro-rough surface implants: a review of literature and meta-analysis.	Clin Oral Implants Res 2014; 25: 539-545 [Epub 2013]	To test the hypothesis that 6 mm micro-rough short Straumann(®) implants provide predictable survival rates and verify that most failures occurring are early failures.
Sun et al. (2011)	Failure rates of short (≤ 10 mm) dental implants and factors influencing their failure: a systematic review.	Int J Oral Maxillofac Implants 2011; 26: 816-825	To evaluate the long-term failure rates of short dental implants (≤ 10 mm) and to analyze the influence of various factors on implant failure.
Telleman et al. (2011)	A systematic review of the prognosis of short (<10 mm) dental implants placed in the partially edentulous patient.	J Clin Periodontol 2011; 38: 667-76	To evaluate, through a systematic review of the literature, the estimated implant survival rate of short (
van Oirschot et al. (2012)	Long-term survival of calcium phosphate-coated dental implants: a meta-analytical approach to the clinical literature.	Clin Oral Implants Res 2013; 24: 355-62 [Epub 2012]	To systematically appraise and (2) to meta-analyse long-term survival data of calcium phosphate-coated dental implants in clinical trials
Vouros et al. (2012)	Systematic assessment of clinical outcomes in bone-level and tissue-level endosseous dental implants.	Int J Oral Maxillofac Implants 2012; 27: 1359-1374	To address what are the clinical and radiographic outcomes of bone-level (BL) implants in comparison to tissue-level (TL) implants after restoration with dental prostheses
Wennerberg & Albrektsson (2009)	Effects of titanium surface topography on bone integration: a systematic review.	Clin Oral Implants Res 2009; 20 Suppl 4: 172-184	To analyse possible effects of titanium surface topography on bone integration.

Table 3. Treatment outcomes, edentulous maxilla

Immediate

Surgical complications

Prosthodontic complications

Late

Dissatisfaction with function

- Speech / Chewing ability / Other (e.g., saliva spray)

Dissatisfaction with appearance

- Prominent chin (“bulge”)
- Sunken profile (posterior medial modiolus, large naso-labial angle, marked naso-labial fold)
- Teeth not showing
- Upper lip not showing (orbicularis oris collapse)
- Transition line prosthesis-tissue visible upon smiling

Occlusally related

- Even functional occlusion (articulation)
- Over-closure
- Pain in TMJ - possibly due to incorrect VDO

Biological adverse outcome

- Ulcers/ soreness / bleeding – possibly due to lack of OH access
- Inflammatory peri-implant diseases

Technical adverse outcome

- Supraconstruction
- Ill-fit supraconstruction to implants
- Implant system components wear and breakdown

Cost /fiduciary aspects

Maintenance needs

Table 4. Appraisal of risk of potential bias in individual studies.

1. Is there a clearly stated study objective that matches the reported outcome?	1	?	0
2. Is the study design appropriate with respect to the stated study objective?	1	?	0
3. Has an ethics board approved the study?	1	?	0
4. Are the characteristics of the study participants clearly described?	1	?	0
5. Is there a risk of selection bias – are the inclusion and exclusion criteria clearly described?	1	?	0
6. Are all steps of the intervention clearly described – if comparative, are all participants treated according to the same intervention (apart from factor of interest)?	1	?	0
7. Are the outcomes clearly described – are adequate methods used to assess these outcomes?	1	?	0
8. Has blinding been used when outcomes have been assessed?	1	?	0
9. Is the follow-up rate satisfactory?	1	?	0
10. Are all participants accounted for?	1	?	0
11. Can selective loss-to follow-up likely be excluded?	1	?	0
12. Are the most important confounders or prognostic factors identified and are these taken into consideration with respect to the study design and analysis?	1	?	0
13. Are the statistical analyses appropriate in light of the study objective, test assumptions and choice of statistical unit?	1	?	0
14. Is the funding source for the study declared?	1	?	0

Table 5. Subcategories of reports based on characteristics of study design as well as strategy for surgical intervention.

Study Criteria	Identified	Not Included	Excluded	Included
Designed with objective to assess effects of implant design or -feature on outcomes (All categories of the Cawood-Howell bone classification system)[18-34]	196	77	102	17
Report effects of tilted implants to enable placement of longer implants (All categories of the Cawood-Howell bone classification system)[35-57]	46	21	2	23
Report effects of implants placed in zygomatic bone with or without additional alveolar implants (Predominantly Cawood-Howell bone class V and VI)[58-87]	56	26	0	30
Report effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants (Predominantly Cawood-Howell bone class V and VI)[88-96]	13	4	0	9
Report bone augmentation with simultaneous or delayed implant placement (Predominantly Cawood-Howell bone class V and VI)[97-112]	165	92	57	16
No *a priori* stated objective to assess a particular implant design or feature (All categories of the Cawood-Howell bone classification system)[113-122]	522	253	259	10
Total	998	473	420	105

Table 6. Characteristics of studies designed with an objective to assess effects of implant design (/-feature) on outcomes

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Jungner et al. (2014-2012e)[18]	Edentulous(31p 148i) Partial_edentate(39p 103i) Single(33p36i) mandible maxilla	2001-2002	Private practice, Umeå, Sweden	103	287	8-5, average 7	Brånemark-Mk3-turned(133i) /-Mk3-TiU(154i)
Vervaeke et al. (2013e)[19]	Terminal / Edentulous mandible(52p, 269i) maxilla(39p,250i)	2002-2008	University clinic, Milano, Italy	80	519	9-4, average 7	3i_ø3.25/3.75/4/5mm_L8.5/10/11.5/13/15mm
Testori et al. (2013e)[20]	Edentulous(736i) Partial_dentate(419i) Single(165i) // Mandible(563i) Maxilla(757i)	2004-2007	Private practice	376	1320	6-0, average 3	Osseospeed_ø3.5/4.0/4.5/5.0mm_L8-17mm
Ravald et al. (2013)[21]	Edentulous Mandible(32p, 165i) Maxilla(34p, 206i)	1993-1995	Public Health, Linköping, Sweden	66	371	15-12, average 7	Astra-TiO(184i)_ø3.5mm_L9-19mm vz. Brånemark-Mk2(187i)_ø3.75/4.0mm_L10-18mm
Van Assche et al. (2012-2011e)[22]	Edentulous maxilla	Not reported	University Clinic, Leuven, Belgium	12	72	2	StraumannStdPlus-SLActive_ø3.3/4.1mm_L6/10/12/14mm
Cosyn et al. (2012-2010e)[23]	All categories	2004-2007	University Hospital, ghent, Belgium	461	1180	4-1, average 2.5	3i(125i), Astra(174i), NobelB(442i) Dentsply(183i), Straumann(266i)_ø3-6.0mm_L6-18mm
Kallus et al. (2009-2008e)[24]	Edentulous Mandible(358i) Maxilla(222i)	Not reported	Private practice, Stockholm, Sweden	60	580	5	Brånemark-Mk2(290i) (Lifecore)Restore(359i)_ø/L_n.r.
Li et al. (2009)[25]	Terminal/ Edentulous mandible(63p,371i) maxilla(48p,319i)	2001-2007	Private practice, Hong Kong	111	690	6-1, average 2	Brånemark-Mk3(256i) /-Mk4/NobelSpeedy(64i) ReplaceSelectTaper/NobelReplace(359i) /-Straigtht(11i)
Alsaadi et al. (2008b)[26]	All categories	Not reported	University Clinic, Leuven, Belgium	412	1514	2	Brånemark-turned(1316i) /-TiU(198i)_ø3.3/3.75/4/5mm_L10mm (107/1514 < 10mm)
Nelson et al. (2008)[27]	Edentulous mandible/ maxilla(418i) Partial_dentate Mandible/Maxilla(114i)	2000-2005	University clinic, Berlin, Germany	117	532	5-2, average 3.75	Camlog-Rootline(410i) /-Screwline(53i) vz. Straumann-solidscrew(69i)_ø3.3-6.0mm_L8-16mm
Malo et al. (2007)[28]	Edentulous(54i) Partial_dentate(296i) single (58i) / mandible(278i) maxilla(130i)	1996-2004	Private practice, Lisbon, Portugal	237	408	9-1, average 5	Brånemark-Mk2 /-Mk3 /-Mk4/NobelSpeedyShorty-Turned(272i) /-TiU(136i)_ø3.75/4.0mm_L7/8.5mm
Hjalmarsson & Smedberg (2005)[29]	Edentulous mandible maxilla	1999-2000	Public Health, Stockholm, Sweden	46	276	3	Astra(135i) Brånemark(141i)
Degidi et al. (2005)[30]	Terminal / Edentulous maxilla	1995-1999	Private practice, Bologna, Italy	45	388	5	Not reported_ø3.8-5.5mm_L10mm
Schwartz-Arad et al. (2004)[31]	Terminal / Edentulous mandible(22p,150i) maxilla(31p,228i)	1989-1996	University Clinic, Tel Aviv, Israel	44	381	8.5-1, average 3	"HA-coated"/"cpTi"_ø-n.r._L13mm
Morris et al. (2001)[32]	All categories	1991-	Multicentre (30): Veterans Affairs Medical Centers, USA	829	2955	4	BioVent(MdE:319i+MxP:172i+MdP:420i) CoreVent(MdE:291i+MdP:328i) MicroVent-HA(MxE:247i+MxP:249i) ScrewVent-HA(MxE:185i) /-CPTi(MxE:199i /-tiA(MdE:294i)
Friberg et al. (1997)[33]	Edentulous mandible(69p, 363i)	1987-1990	Multicentre (3):, Public Health.	103	563	5	Brånemark-Std(275i) /-Mk2(288i)__ø3.75/4.0mm_L7-20mm

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
	maxilla(33p, 200i)		Sweden				
Olsson et al. (1995)[34]	Edentulous Mandible(70p,363i) Maxilla(33p,200i)	1987-1990	Multicentre (3): Public Health, Göteborg/Skövde/ Umeå, Sweden	103	563	3	Brånemark-std(275i) /-Mk2(288i)_ø3.75/4.0mm_L7-18mm

Implant systems: Ø = diameter, L = Length

Table 7. Characteristics of studies reporting the effects of tilted implants to enable placement of longer implants

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Agliardi et al. (2014-2012e)[35]	Terminal (44i) / Edentulous maxilla_posterioratrophy	2005-2008	Not reported	32	192	6.5-3, average 4.5	Brånemark-Mk4-TiU(30i) NobelSpeedyGroovy(162i)_ømm_L11.5/13/15mm
Agnini et al. (2014-2012e)[36]	Terminal / Edentulous mandible(16p) maxilla(20p)	2006-2010	University Clinic, Foggia, Italy	30	272	5.5-1.5, average 3.5	(Zimmer)Spline(84i) ScrewVent-taper(188i)
Pera et al. (2014)[37]	Terminal -> Edentulous Maxilla	2005-2006	University Clinic, Genova, Italy	37	164	6	Osseotite(108i) /-NT(56i)+/-Coronal-etching_ø4.0mm_L>13mm
Pozzi et al. (2013e)[38]	Edentulous mandible(61p) maxilla(34p)	2003-2012	University Clinic, Milano, Italy	86	344	9-1, average 5.5	Not reported
Malo et al. (2013)[39]	Terminal / Edentulous mandible(48p 192i) maxilla(38p 152i)	2008-2011	University Clinic, Beijing, China	69	344	4.5-1, average 3	Brånemark-Mk2-TiU(52i) NobelSpeedyGroovy(202i)_ø-n.r._L10-12mm
Testori et al. (2013)[40]	Edentulous maxilla_atrophy_heigth <5mm-bone	2005-2010	Private practice, Lisbon, Portugal	70	280	3	NobelSpeedy_ø4mm_L10/13/15/18mm
Di et al. (2013)[41]	Edentulous(32p)/Partial_dentate(3p) maxilla_atrophy_CH5	Not reported	Not reported	35	190	10-0, average 5	Not reported_ø4mm_L13/15mm
Malo et al. (2012-2011e)[42]	Terminal / Edentulous maxilla	2002-2006	Private practice, Lisbon, Portugal	242	968	5	Brånemark-Mk3(21i) /-Mk4-TiU(82i)U NobelSpeedy(865i)_ømm_L10-18mm
Francetti et al. (2012-2010e)[43]	Terminal / Edentulous mandible(33p,132i) maxilla(16p,64i)_LZ-A/B/C	2004-2008	Multicentre (2): Not reported	47	196	5.5-2.5 average 4	Brånemark-Mk4-TiU(92i-all md.) NobelSpeedyReplace(104i)_ø4.0mm_L10-18mm
Mozzati et al. (2012)[44]	Terminal / Edentulous Mandible(20p,80i) Maxilla(24p,96i)_posterioratrophy	2007-2007	University Clinic, Milano, Italy	36	176	3	(Sweden&Martina)PAD_ø3.75/4.0mm_L13/15mm
Crespi et al. (2012)[45]	Terminal / Edentulous maxilla	2001-2009	University Clinic, Torino, Italy	65	334	2	Not reported("ext.hex")_ø4.0mm_L11.5/13/15/18mm
Cavalli et al. (2012)[46]	Terminal / Edentulous maxilla_posterioratrophy	2007-2011	Not reported	34	136	6-1, average 3	Brånemark-Mk4-TiU NobelSpeedyGroovy
Malo et al. (2012)[47]	Terminal(18i) / Edentulous mandible(94i) maxilla(133i)	2003-2009	Private practice, Lisbon, Portugal	142	227	3-1, average 2	Brånemark-Mk3-TiU /-Mk4-TiU NobelSpeedy_ø3.3/4.0mm_L>10mm
Malo et al. (2011)[48]	Terminal(31p,45i) / Edentulous Maxilla_posterioratrophy-levels1-4	1998-2006	Private practice, Lisbon, Portugal	221	995	5	Brånemark-Mk2 /-Mk3 /-Mk4 NobelSpeedy_ø3.3/4.0mm_L10-18mm
Agliardi et al. (2010)[49]	Edentulous Mandible(93p,404i) Maxilla(61p,288i)_atrophy	2004-2009	Private practice, Bollate, Italy	173	616	5-1, average 3.5	Brånemark-Mk4-TiU(92i) NobelSpeedyGroovy(600i)_ømm_L8.5/10/11.5/13/15/18mm
Degidi et al. (2010)[50]	Edentulous maxilla	2005-2006	Private Practice, Bologna, Italy	30	210	3	XiVEPlus_ø3.4/3.8mm_L10-16mm
Pomares	Terminal / Edentulous Mandible(9p,36i)	2004-2006	Private practice, Alicante, Spain	20	127	2	NobelSpeedyMk3Groovy_ømm_L≥13mm

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
(2009)[51]	Maxilla(19p,91i)						
Agliardi et al. (2009)[52]	Terminal / Edentulous maxilla	2005-2007	Not reported	20	120	3.5-1.5, average 2	Brånemark-Mk4-TiU(30i) NobelSpeedyGroovy(90i)_ø4.0mm_L 11.5/13/15mm
Rosen & Gynther (2007)[53]	Edentulous maxilla_atrophy_CH5/6	1998-	University Clinic, Stockholm, Sweden	19	103	12-8, average 10	Brånemark-Mk2_ø3.75mm_L7/10-18mm
Capelli et al. (2007)[54]	Edentulous mandible(24p,96i) maxilla(41p,246i)_atrophy	2002-2006	Multicentre (4): Private practices, Italy	65	342	4.5-0, average 2	Osseotite-NT-n.r.
Fortin et al. (2002)[55]	Edentulous maxilla	1991-1994	Private Practice, Quebec, Canada	45	245	5	Brånemark_ø3.75mm_L7/8.5/10/12/13/15/18mm
Krekmanov et al. (2000)[56]	Edentulous/Partial_dentate mandible(25p,78i) maxilla(22p,138i)	Not reported	Public Health, Västerås, Sweden	47	206	5-3, average 4	Brånemark_n.r.
Mattsson et al. (1999)[57]	Edentulous maxilla_atrophy_CH5/6	1998-	University Clinic, Stockholm, Sweden	15	68	4.5-3, average 4	Brånemark-Mk2_ø3.75mm_L7/10-18mm

Implant systems: Ø = diameter, L = Length

Table 8. Characteristics of studies reporting the effects of implants placed in zygomatic bone with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Yates et al. (2014-2013e)[58]	Edentulous maxilla_atrophy_height <6mm-bone	2000-2006	Not reported	25	43	10-5, average 6	Brånemark-Zygomatic-turned_ø4-4.5mm_L8mm
Aparicio et al. (2014-2012e)[59]	Edentulous maxilla_atrophy	1998-2002	Private practice, Barcelona, Spain	22	172	10	Brånemark-Mk3 /-pter(29i)(131i)_ø3.3-4mm_L7-18mm + Brånemark-Zygomatic-turned(41i)_L30-50mm
Fernandez et al. (2014)[60]	Edentulous Partial_dentate maxilla	2009-2013	University Hospital, Bogotá, Colombia	80	244	4-0.5, average est. 2	Not reported
Malo et al. (2013e)[61]	Edentulous maxilla_atrophy_CH5/6/>6	2006-2012	Private practice, Lisbon, Portugal	352	1542	7-0.5, average 2.5	NobelSpeedy(795i) + (NobelB)Zygoma-TiU
Davo et al. (2013)[62]	Edentulous maxilla_atrophy_CH4/5/6	2006-2009	Private practice, Alicante, Spain	17	68	3	Brånemark-zygomatic_L30-52.5mm
Davo & Pons (2013)[63]	Edentulous(37p) Partial_dentate(5p) maxilla_atrophy	2004-2006	Private practice, Alicante, Spain	42	221	5	Brånemark-TiU(108i) Replace(32i)_ø3.75/4/4.3/5mm_L10-16mm + Brånemark-Zygomatic-turned(44i) /-TiU(37i)_L40-52.5mm
Malo et al. (2012)[64]	Edentulous maxilla_atrophy_CH5/6	2006-2009	Private practice, Lisbon, Portugal	39	169	3	Nobel-TiU(77i) + (NobelB)Zygoma-TiU Prototype1/Prototype2(92i)_ø5mm
Miglioranca et al. (2012)[65]	Edentulous maxilla_atrophy	2003-2006	Private practice, Sao Paulo, Brazil	25	114	8	NobelReplace-taper(74i) + Brånemark-Zygomatic(40i)
Balshi et al. (2012)[66]	Edentulous maxilla	Not reported	Private practice, Fort Washington, USA	77	173	10-1, average	Brånemark-Mk3/-Pter(391i) + Zygoma-turned(76i)/-TiU(34i)_ømm_L30-52.5mm
Aparicio et al. (2010-2008e)[67]	Edentulous maxilla_atrophy	Not reported	Private practice, Barcelona, Spain	25	176	5-2,	NobelB-TiU(129i)_ø3.75/4.0mm_L7-18mm + (NobelB)Zygomatic-turned(47i)_L35-52.5mm
Aparicio et al. (2010-2008e)[68]	Edentulous/Partial_dentate Maxilla_atrophy	2004-2005	Private practice, Barcelona, Spain	20	140	4-3, average 3.5	NobelB-TiU(104i)_ø3.75/4.0mm_L7-18mm + Brånemark-Zygomatic-turned(36i)_35-52.5mm
Bedrossian (2010)[69]	Edentulous maxilla_atrophy	2003-2005	Not reported	36	172	7-0.5, average	Brånemark-Mk4(54i), NobelSpeedy(44i)_ø4.0mm_L7-13mm + Brånemark-Zygomatic-turned(74i)_L30-52.5mm
Stievenart & Malevez (2010)[70]	Edentulous maxilla_atrophy_LZ-D/E	Not reported	Not reported	20	80	3.5-0.5, average	Brånemark-Zygomatic_L30-52.5mm
Davo (2009)[71]	Edentulous maxilla_atrophy	1999-2003	Private practice, Alicante, Spain	24	154	5	Brånemark-Mk3-turned(79i)/-TiU(30i)_ø3.75/4.0mm_L10-15mm + Brånemark-Zygomatic-turned(45i)_L40-50mm
Balshi et al. (2009)[72]	Edentulous maxilla_atrophy	Not reported	Private practice, Fort Washington, USA	56	501	5-0.5,	Brånemark-Mk3/-Pter(391i) + Zygoma-turned(76i)/-TiU(34i)_ømm_L30-52.5mm
Pi Urgell et al. (2008)[73]	Edentulous/Partial_dentate Maxilla_atrophy	2004-2006	Private practice, Alicante, Spain	42	221	3.5-1, average 2	Brånemark-TiU(108i) Replace(32i)_ø3.75/4/4.3/5mm_L10-16mm + Brånemark-Zygomatic-turned(44i) /-TiU(37i)_L40-52mm

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Davo et al. (2008a)[74]	Edentulous maxilla_atrophy	Not reported	Private practice, Alicante, Spain	36	196	3.5-1, average 2	Brånemark(125i) + Brånemark-Zygoma-turned(44i) /-TiU(27i)
Davo et al. (2008b)[75]	Edentulous maxilla_atrophy_CH4/5	1998-2004	Private practice, Barcelona, Spain	54	325	6-0, average 3	Brånemark-std(221i) + (NobelB)-Zygoma(101i)_ø4mm-apex/4.5coronal_L30-52.5mm
Kahnberg et al. (2007)[76]	Edentulous maxilla_atrophy	Not reported	University Clinic, Bahia, Brazil	12	48	2.5 & 0.5, average n.r.	Brånemark-Zygomatic-turned_ø4-5mm
Duarte et al. (2007)[77]	Edentulous/Partial_dentate Maxilla_atrophy	1997-1999	Multicentre (18): Private/Public/University International	60	145	3	Brånemark /-Zygomatic(103i)_ø4.0apex/5.0alv.mm_L35-50mm
Penarrocha et al. (2007)[78]	Edentulous maxilla_atrophy	2000-2005	University Clinic, Valencia, Spain	21	129	4-1, average 2	Defcon/(Straumann)ITI(89i) + Brånemark-Zygomatic(40i)
Penarrocha et al. (2007)[79]	Edentulous maxilla_atrophy	1998-2004	University Clinic, Valencia, Spain	46	321	3.5-1, average 2	Defcon(122i) (Straumann)ITI(155i) + Brånemark-Zygomatic(44i)_L30-42.5mm
Bedrossian et al. (2006)[80]	Edentulous maxilla_atrophy	1999-2001	Public Health, Bergen, Norway	13	55	4-1, average n.r. est. 2	Brånemark-Mk2/-Mk3/-TiU(30i) + Brånemark-Zygomatic(25i)_L35-50mm
Farzad et al. (2006)[81]	Edentulous maxilla_atrophy_LZ-B/C	2003-2004	University Clinic, San Francisco, USA	14	83	3-1, average 2	Brånemark-Mk4-TiU(55i)_ø4.0mm_L7-13mm + Brånemark-Zygomatic(28i)_L35-52.5mm
Ahlgren et al. (2006)[82]	Edentulous maxilla_atrophy	2000-2002	Public Health, Västerås, Sweden	11	64	4-1.5, average 3	Brånemark(42i) + Brånemark-Zygomatic(22i)
Aparicio et al. (2006)[83]	Edentulous (66p) Partial_dentate (3p) maxilla_atrophy	Not reported	Private practice, Barcelona, Spain	69	435	5-0.5, average	Brånemark-Mk3 /-pter(84i)(304i)_ø3.75/4.0mm_L7-18mm + Brånemark-Zygomatic(131i)_ø4.0mmapex/5.0mm alv._L35-52.5mm
Becktor et al. (2005)[84]	Edentulous maxilla_atrophy_CH5/6	1998-2002	Public Health, Halmstad, Sweden	16	105	5.5-0.9, average 4	Astra/Brånemark(74i) + Brånemark-Zygomatic(31i)_L30-50mm
Malevez et al. (2004)[85]	Edentulous maxilla_atrophy	1990-1995	University Clinic, Göteborg, Sweden	28	158	10- 5	Brånemark(106i) + Brånemark-BOC/Expro-Zygoma(52i)_ø4.0apex/4.5(cor.)mm_L30-50mm
Brånemark et al. (2004)[86]	Edentulous maxilla_atrophy	1997-2001	University Clinic, Brussels, Belgium	55	297	4-0.5, average 2.5	Brånemark-std(194i)_ø3.75mm + Brånemark-Zygomatic(103i)_ø4.0apex/5.0alv.mm_L35-50mm
Bedrossian et al. (2002)[87]	Edentulous maxilla_atrophy	Not reported	Not reported	22	124	3	Brånemark-Mk3(80i)_ø3.75mm_L10/13mm + Brånemark-Zygomatic(44i)_L40-50mm

Implant systems: Ø = diameter, L = Length

Table 9. Characteristics of studies reporting the effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Penarrocha-Oltra et al. (2013)[88]	Edentulous Maxilla_atrophy_CH5	2000-2004	University Clinic, Valencia, Spain	33	222	5	(Phibo)TSA-Avantblast
Balshi et al. (2013b)[89]	Terminal / Edentulous Maxilla	1985-2011	Private practice, Fort Washington, USA	981	1608	25-1, average 10+	Astra(7i) Brånemark-std /-Mk2 /-Ebon /-Mk3 /-Mk4 /-turned /-TiU(1601i)_ø3.75/4.0/5.0mm_L7-18mm
Balshi et al. (2013a)[90]	Edentulous/Partial_dentate/Single maxilla_posterior	1985-2011	Private practice, Fort Washington, USA		992	10-1, average 6	Brånemark-Pterygoid_ø4mm_L7-13/15-18mm
Rodriguez et al. (2012)[91]	Edentulous Partial_dentate Maxilla_<8mm_bone-to-sinus	1997-2010	Private Practice, Barcelona, Spain	392	454	14-0, average 6	Osseotite-Pterygoid_ø3.75/4.0mm_L15/18/20mm
Penarrocha et al. (2012)[92]	Edentulous maxilla_atrophy_CH4/5	2002-2010	University Clinic, Valencia, Spain	18	117	7-1, average 3	(Sentmenat)Phibo_ø3.5/4.1/4.2/5.5_L10/11.5/13mm (NobelB)Zygoma(4i)_L35/45mm
Penarrocha et al. (2009)[93]	Edentulous maxilla_atrophy_CH4/5	2000-2004	University Clinic, Valencia, Spain	74	490	4-2, average 3	(Impladent)Defcon-Avantblast_ø3.6/4.2mm_L10/11.5/13/14.5mm (NobelB)Zygoma(36i)
Penarrocha et al. (2009)[94]	Edentulous(23p) Partial_dentate(22p) maxilla_atrophy_CH4/5	2000-2006	University Clinic, Valencia, Spain	45	268	5-1, average 3	(Impladent)Defcon-Avantblast(25p,37i), (Straumann)ITI(20p,31i)_ø3.6/4.2mm_L10/11.5/13/14.5mm /-pterygoid(68i)
Balshi et al. (2005a)[95]	Terminal / Edentulous maxilla	1999-2004	Private practice, Fort Washington, USA	82	840	4.5-0.5, average 2.5	Brånemark-Mk3-TiU(28p,251i)_ø3.75/4mm_L7-15mm /-Mk4-TiU(136p,379i)_ø4mm_L7-18mm /-Zygoma-turned(46i)_L30-50mm
Balshi et al. (1999)[96]	Edentulous maxilla	Not reported	Private practice, Fort Washington, USA	189	1817	6-1.5, 4.5 average	Brånemark-std /-selftap _ø3.75/(4.0/5.0)mm_L(10/13)/15/(18)mm

Implant systems: Ø = diameter, L = Length

Table 10. Characteristics of studies designed to report effects of bone augmentation with simultaneous or delayed implant placement reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Zinser et al. (2013-2012e)[97]	Edentulous(278i) Partial_dentate(642i) Single(124i) Maxilla_Posterior_atrophy_CH2-6	1995-2009	Public Health, Amstelveen, The Netherlands	224	1045	14	"additive" & "ablative"_ø3.3/3.8/4/4.4/4.5/5mm_L11/12/13/14/15/16mm
Dasmah et al. (2013-2011e)[98]	Edentulous maxilla_atrophy_CH6	1999-2001	Public Health, Stockholm, Sweden	19	152	5	Astra-TiO_ø3.5mm_L9/11/13/15/17mm
Sjöström et al. (2007)[99]	Edentulous maxilla_atrophy_CH2-6	Not reported	University Clinic, Umeå, Sweden	29	222	3	Brånemark-Std(171i) /-Mk2(21i)_ø3.75mm_L10-18mm
Chiapasco et al. (2007)[100]	Edentulous maxilla_atrophy_CH6	1995-2004	Multicentre (3): University, Milano, Italy	39	281	9-1, average 4	Brånemark, (Friadent)Frialit, IMZ, (Straumann)ITI
Hallman et al. (2005)[101]	Edentulous maxilla_atrophy_CH6	1993-1995Brånemark - 1995-1997Astra	Public Health, Gävle, Sweden	22	156	5	Astra-TiO(11p, 72i)_ømm_L8/9/11/13/15 Brånemark-Mk3-turned(11p, 84i)_ø_L7/10//13/15mm
Becktor et al. (2004)[102]	Edentulous maxilla_atrophy_CH3/4 (22p) _5/6(41p)	1990-1996	Public Health, Halmstad, Sweden	182	1120	9-2, average 6.5	Brånemark_ø3.75/4/5mm_L6/7/8/10/13/15/18mm
Pinholt (2003)[103]	Edentulous(11p) Partial_dentate(14p) maxilla_atrophy_LekZarb-D/E	1996-1998Brånemark - 1998-2000Straumann	Public health, Vejle, Denmark	25	158	5.5-2, average not reported	Brånemark-std/Mk2/Mk3-turned(12p,78i)_ø?mm_L8.5-18mm and (Straumann)ITI-SLA(13p,80i)_ø?mm_L8-16mm
Becktor et al. (2002)[104]	Edentulous maxilla_atrophy_CH3-6	1990-1996	Multicentre (2): Public Health, Rochester, USA & Halmstad, Sweden	90	643	9-2, average 5	Brånemark-Std /-Con /-Mk2_ø3.75/4.0/5.0mm_L7/8/10/13/15/18/20mm
Lekholm et al. (1999)[105]	Edentulous(28p) Partial_dentate(4p) maxilla_compromised	1984-1997	Public Health, Rochester, USA	32	204	11-1, average 5	Brånemark-Std /-Con /-Mk2_ø3.75/4.0mm_L15/18mm
Keller et al. (1999)[106]	Edentulous Partial_dentate maxilla	1984-1996	Public Health, Rochester, USA	54	248	11-1, average 5	Brånemark-Std /-Con /-Mk2_ø3.75/4.0mm_L10/13/15/18/20mm
Keller et al. (1999)[107]	Edentulous maxilla_atrophy_LekZarb-D	1991-	Multicentre (23): Scandinavia	150	781	3	Brånemark-Std /-Con /-Mk2_ø3.75/4.0mm_L15/18mm
Watzek et al. (1998)[108]	Edentulous Maxilla_Posterior_atrophy_CH6	1989-1995	University Clinic, Wien, Austria	20	155	6-1	(Friatec)Frialen(70i) (Friatec)IMZ(85i)
Nyström et al. (1997)[109]	Edentulous maxilla_atrophy_CH5/6	Not reported	University Clinic, Umeå, Sweden	10	60	3-1, average	Brånemark-Mk2_ø3.75mm_L13/15/18mm
Köndell et al. (1996)[110]	Edentulous maxilla_atrophy_<7mm-bone-post.	Not reported	University Clinic, Stockholm, Sweden	14	75	5	Brånemark-selftap_ø3.75mm_L7-15mm
Neukam (1996)[111]	Edentulous maxilla_atrophy_LekZarb-D/E	1987-1993	University Clinic. Erlangen-Nurnburg,	43	284	6-3	Brånemark_ømm_L7/10/12/13/15/18mm

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
			Germany				
Keller et al. (1994)[112]	Edentulous Partial_dentate Maxilla_atrophy	1984-	Public Health, Rochester, USA	20	83	6-1, average 2	Brånemark-Std /-Con /-Mk2_ ø3.75/4.0mm_L10/13/15/18/20mm

Implant systems: Ø = diameter, L = Length

Table 11. Characteristics of studies designed with no *a priori* stated objective to assess a particular implant design feature

Lead author	Patient situation	Year placed	Setting	n-pat	n-implant	Time (yrs)	Implant system(s)
Jemt et al. (2011)[113]	Edentulous maxilla_LZ_B/C	1986-1987Turned - 2001-2004Oxidized	Public Health, Göteborg, Sweden	165	1120	5	Brånemark-Std /-Mk2 /-Mk3 /-Mk4 (450i+360i) /-TiU(310i)_ø3.75/4.0mm_L7/8.5/10/11.5/13/15/18/20mm
Friberg & Jemt (2008-2007e)[114]	Edentulous maxilla wide (n=33p 226i) vs. _atrophy_narrow_LZ_C/D (n=42p 279i)	1993-1997	Public Health, Göteborg, Sweden	75	506	7	Brånemark-std/-selftap/-Mk2/-Mk3-turned_ø3.75/4.0/5.0mm_L6/7/8.5/10/11.5/13/15/18/20mm (72≤8.5mm)
Jemt & Johansson (2006)[115]	Edentulous maxilla	1986-1987	Public Health, Göteborg, Sweden	76	450	15	Brånemark-std_ø3.75mm_L7-18mm (106i/430<10mm)
Widbom et al. (2005)[116]	Edentulous maxilla	1993-2002	Public Health, Skövde, Sweden	27	145	9-4 average 5.5	Brånemark-Mk2_L7-18mm
Ibanez et al. (2005)[117]	Edentulous mandible(126i) maxilla(217i)	1998-2004	Multicentre (3): University clinic & Private practices, Cordoba, Spain	41	343	6-0.5, average 2.5	Osseotite /-NT /-XP_ø3.75/4.0/≥5.0mm_L≤10/>10mm (74≤10mm)
Degidi & Piattelli (2003)[118]	Edentulous mandible (39p) maxilla(14p) Partial_dentate Mandible_post(23p) Maxilla_pos(15p) Single(58i)	1996-2001	Private practice, Bologna, Italy	152	646	5-0.5, average 2	Frialit2 (144i) Frialoc(37i) IMZ(51i) Brånemark(73i) Maestro(242i) Restore(97i)
Kiener et al. (2001)[119]	Edentulous maxilla	1991-1998	Not reported	41	173	5-1, average 3	(Straumann)ITI_ø3.3/4.1/4.8mm_L6/8/10/12mm
Watson et al. (1998)[120]	Edentulous mandible(30p, 90i) maxilla(14p,43i)	1990-1994	Not reported	43	139	6-3, average 4	(Calcitek)Integral-HA_ø3.25/4.0mm_L8/10/13/15mm
Jemt & Lekholm (1995)[121]	Edentulous Maxilla & maxilla_atrophy_severe/intermediate	1985-1988	Not reported	150	801	5	Brånemark-std /-selftap /-con_ø3.75mm_L7/10/≥13mm, (298/801<10mm)
Palmqvist et al. (1994)[122]	Edentulous maxilla	1985-1992	Public Health, Örebro, Sweden	25	59	5-1, average 3	Brånemark_ø3.75mm_L7/10/13/15/18/20mm

Implant systems: Ø = diameter, L = Length

Table 12. Bias assessment of studies designed with an objective to assess effects of implant design or -feature on outcomes

Lead author	Study objective	Study design	statistics	REB	Funding	Bias risk
Jungner et al. (2014-2012e)[18]	to compare the clinical performance of turned and oxidized implants after more than 5 years of loading	Retrospective case series	ANOVA	Not reported	None declared	High
Vervaeke et al. (2013e)[19]	2: To identify predictors affecting implant treatment outcomes using multivariate tests that correct for confounding	Retrospective case series	MannWhitney+LogRank+CoxRegression+LinearMixedEffect	Ghent University Hospital	None declared	Medium
Testori et al. (2013e)[20]	to assess the reliability of immediate implant and immediate loading (IL) protocols in the edentulous jaws. A further aim was to investigate the role of patient-related, implant-related, and surgery-related secondary variables in the occurrence of implant failure.	Retrospective case series	MannWhitney+Kaplan-Meier+CoxRegression	IRCCS Scientific Review board	None declared	Medium
Ravald et al. (2013)[21]	To study the long-term outcome of implant survival rate, soft and hard tissue conditions and prosthetic status in a group of individuals treated with either Astra Tech TiOblast or Brånemark turned implants supporting a full-arch bridge.	RCT Randomized controlled trial, 2 arms (Astra vs Brånemark)	Wilcoxon+LifeTable	EC of Linköping University	Astra Tech AB, Sweden & Research Council of Public Dental Services, Östergötland, Sweden	Low
Van Assche et al. (2012-2011e)[22]	To investigate the outcome of short implants additionally placed with longer implants to support a maxillary overdenture	CCT Prospective study w/ concurrent controls Split (Short distally vs long anterior)	ANOVA+LinearMixedModels-incl.Dunnett-multiple tests	Not reported	Institut Straumann AG, Switzerland	High
Cosyn et al. (2012-2010e)[23]	To explore Factors Associated with Failure of Surface-Modified Implants using data obtained in a university postgraduate training center	Retrospective case series	FisherExact+Kaplan-Meier+LogRank+CoxRegression+LogisticRegression	University Hospital Ghent	None Declared	Medium
Kallus et al. (2009-2008e)[24]	To compare survival rates and marginal bone resorption of the Lifecore Restore Implant System with the benchmark Nobel Biocare MK II Implant System	Retrospective case series (Lifecore) w/ historical controls (Nobel Biocare)	Chi²/FisherExact+Kaplan-Meier	Not reported	None declared	High
Li et al. (2009)[25]	To describe immediate functional loading of completely edentulous maxillas and mandibles by fixed provisional prostheses and to compare cumulative survival rates between maxillas and mandibles.	Retrospective case series	FisherExact/t-test	Not reported	None declared	High
Alsaadi et al. (2008b)[26]	To evaluate the success rate of 2 different implant systems with sandblasted and acid-etched modified surfaces loaded after reduced healing times	Retrospective case series	Chi²/t-test+Kaplan-Meier	Not reported	None declared	High
Nelson et al. (2008)[27]	To assess he influence of systemic and local bone and intra-oral factors on the occurrence of implant loss from abutment connection up to 2 years	Retrospective case series	Logistic Regression	Not reported	None declared	Medium
Malo et al. (2007)[28]	To report on the placement of short Branemark implants, testing the hypothesis that short implants in atrophied jaws might give similar long-term implant survival rates as longer implants used in larger bone volumes	Retrospective case series	Chi²+LifeTable	Not reported	None declared	High

Lead author	Study objective	Study design	statistics	REB	Funding	Bias risk
Hjalmarsson & Smedberg (2005)[29]	To compare the prosthesis retention screw stability (ie, preload) and the clinical outcome after prosthesis connection in patients treated with traditional frameworks versus frameworks produced with the Cresco Ti Precision method	Retrospective case series	ANOVA/FisherExact/KruskalWallis	Not reported	None declared	High
Degidi et al. (2005)[30]	To evaluate the outcome of implants immediately loaded with a cross-arch fixed temporary restoration in the edentulous upper jaw in a consecutive study population	Retrospective case series	Kaplan-Meier+LogRank+CoxRegression	Not reported	Ministry of Education (MIUR), Italy & National Research Council (CNR), Italy & Research Association for Dentistry (AROD), Italy	Medium
Schwartz-Arad et al. (2004)[31]	To examine the cervical bone loss and its correlation with implant characteristics and anatomic factors, 1 to 8 years post-implantation of immediate and delayed implants	CCT Prospective study w/ concurrent controls (Implant characteristics)	Chi^2/t-test+Kaplan-Meier+Linear Regression	Not reported	None declared	Medium
Morris et al. (2001)[32]	To separately examine a subset of data from the extensive DICRG database to determine what relationship, if any, exists between implant design and survival. Six implant designs were randomized to 5 restorative applications and subsequently evaluated	RCT Randomized controlled trial-split, 2x3+2xarms (Edentulous max: HA-coated grooved vs HA-coated screw vs cpTi-screw / Edent mand: HA-coated cylinder vs Tialloy-basket vs Tialloy screw / Partial edent. Max. Post. HA-coated cylinder vs HA-coated grooved)	Kaplan-Meier+Log-Rank+Breslow	Not reported	US Government	Medium (Hi Dropout)
Friberg et al. (1997)[33]	To compare the clinical and radiographic evaluations of MK II self-tapping implants with standard implants of the Brånemark system after 5 years	CCT Prospective study w/ concurrent controls Split (with and without tapping)	LifeTable	Not reported	None declared	Medium
Olsson et al. (1995)[34]	To evaluate for over 3 years a modified self-tapping implant (Mk II) with improved cutting characteristics used in both maxillae and mandibles	CCT Prospective study w/ concurrent controls Split (Self-tapping vs pretapping implant)	LifeTable	Not reported	None declared (one coauthor is NobelPharma employee)	Medium

Table 13. Bias assessment of studies reporting the effects of tilted implants to enable placement of longer implants

Lead author	Study objective	Study design	statistics	REB	Funding	Bias risk
Agliardi et al. (2014-2012e)[35]	to prospectively evaluate the clinical and radiographic outcomes of immediate full-arch fixed maxillary prosthesis supported by two axial and four tilted implants after 3 years of loading.	Prospective case series	ANOVA/FisherExact/t-test	Not reported	None declared	High
Agnini et al. (2014-2012e)[36]	to evaluate full-arch fixed-dental restorations supported by immediate loaded axial and tilted implants in a single-cohort study. Survival rate of axial and tilted implants was compared.	Prospective case series	ANOVA/t-test	Universita di Foggia EC	None declared	Medium
Pera et al. (2014)[37]	To reports the 6-year outcomes for patients rehabilitated with an immediate loading protocol of the maxilla (Columbus Bridge Protocol).	Prospective case series	Friedman/Wilcoxon/ANOVA+GeneralEstimationEquation(GEE)	Not reported	None declared	Medium
Pozzi et al. (2013e)[38]	to retrospectively evaluate the implant and prosthetic survival and success rates of zirconia-based, implant-supported, screw-retained, cross-arch restorations up to 5 years after placement.	Retrospective case series	FisherExact	Not reported	None declared	High
Malo et al. (2013)[39]	To report the outcome of trans-sinus tilted implants for the rehabilitation of the complete edentulous atrophic maxilla using the All-on-4 concept with immediate loading	Retrospective case series	LifeTable	Ethics Committee for Health, Lisboa	None declared	High
Testori et al. (2013)[40]	To evaluate tilted trans-sinus implants for rehabilitation of the atrophic maxilla.	Retrospective case series	LifeTable	IRCCS ethics and scientific committee	None declared	High
Di et al. (2013)[41]	To evaluate the outcome and special characteristics of immediate implant rehabilitation using the All-on-Four treatment concept in completely or potentially completely edentulous Chinese patients	Prospective case series	LifeTable+LogRank	Beijing Municipal Health Bureau 2008-99	National Program on Key Basic Research (973 Program) China	Medium
Malo et al. (2012-2011e)[42]	to report on the medium- and long-term outcomes of a protocol for immediate function of four implants (All-on-4, Nobel Biocare AB, Göteborg, Sweden) supporting a fixed prosthesis in the completely edentulous maxilla.	Retrospective case series	Kaplan-Meier	"An independent ethical committee"	None declared	High
Francetti et al. (2012-2010e)[43]	to assess clinical outcomes and peri-implant bone level changes around tilted and axial implants supporting full-arch fixed immediate rehabilitations up to 60 months of loading.	Prospective case series	ANOVA/Paired-t	Not reported	None declared	Medium
Mozzati et al. (2012)[44]	To conduct a immediate postextraction implant placement with immediate loading in the maxilla	Retrospective case series	Descriptive	"The local ethics committee"	None declared	High
Crespi et al. (2012)[45]	to compare definitive acrylic resin prostheses with or without a cast metal framework that were immediately loaded and supported by axial and tilted implants in completely edentulous patients after 3 years of function.	RCT Randomized controlled trial, 2 arms (Acrylic Resin framework +/- Metal framework)	t-test	Not reported	None declared	High
Cavalli et al. (2012)[46]	to assess the treatment outcome of immediately loaded full-arch fixed bridges anchored to both tilted and axially placed implants in the edentulous maxilla and to	Retrospective case series	LifeTable	Not reported	None declared	High

Lead author	Study objective	Study design	statistics	REB	Funding	Bias risk
	evaluate the incidence of biological and prosthetic complications.					
Malo et al. (2012)[47]	to document complete rehabilitations in both jaws through the so-called All-on-Four concept (ie, four implants with the posterior implants placed at an angle) using immediate function implants inserted in "nonideal" conditions (eg, implants inserted with dehiscences or fenestrations, in periodontally compromised sites, or in fresh extraction sockets).	Prospective case series	Kaplan-Meier	Not reported	None declared	High
Malo et al. (2011)[48]	To report the long-term outcome of immediately loaded implants in the rehabilitations of completely edentulous maxillae with different classifications	Retrospective case series	Kaplan-Meier+LogisticRegression	Ethics Committee for Health, Lisboa	None declared	Medium
Agliardi et al. (2010)[49]	To evalute the clinical and radiographic outcomes of immediately loaded full-arch fixed prostheses supported by a combination of axially and non-axially positioned implants in a large cohort of patients with completely edentulous jaws, up to 5 years of function	Prospective case series	Chi^2/t-test+LifeTable	Not reported	None declared	High
Degidi et al. (2010)[50]	To evaluate the concept of intraoral welding as a suitable technique for the fabrication of a restoration for the edentulous atrophic maxilla on the day of placement of axial and tilted implants.	Prospective case series	t-test	Not reported	None declared	High
Pomares (2009)[51]	To present clinical results of an implant placement protocol using 4 or 6 implants supporting immediately loaded fixed prostheses.	Retrospective case series	No statistical tests	Not reported	Nobel Biocare research manager, Italy	High
Agliardi et al. (2009)[52]	To report the preliminary results of a single cohort prospective studt that sought to evaluate a new surgical protocol for the immediate rehabilitation of edentulous maxilla without using a bone grafting	Prospective case series	LifeTable	"The institutional review board"	None declared	High
Rosen & Gynther (2007)[53]	To evaluate retrospectively the surgical outcome of tilted implants in severely resorbed edentulous maxillas as an alternative to bone grafting and the prosthodontic outcome of posterior extension bridges on tilted implants.	Retrospective case series	LifeTable	Not reported	None declared	High
Capelli et al. (2007)[54]	To assess the treatment outcome of immediately loaded full-arch fixed bridges anchored to both tilted and axially placed implants for the rehabilitation of fully edentulous maxillae and to compare the outcome of axial vs. Tilted implants.	Prospective case series	t-test+LifeTable	Not reported	None declared	High
Fortin et al. (2002)[55]	To develop a surgical and prosthetic implant treatment protocol for completely edentulous maxiillae in which optimal lip support and phonetics is achieved in combination with substantial implant anchorage without bone grafting	Retrospective case series	LifeTable	Not reported	Nobel Biocare, Sweden	High
Krekmanov et al. (2000)[56]	To modify the method for implant placement in the posterior part of the jaws to extend fixed implant-connected prostheses further distally, and to reduce the length of cantilevers in complete-arch prostheses without transpositioning the mandibular nerve or performing bone grafting in the maxilla	Prospective case series	LifeTable	Not reported	None declared	High

Lead author	Study objective	Study design	statistics	REB	Funding	Bias risk
Mattsson et al. (1999)[57]	To describe the surgical technique for implant treatment in severely resorbed edentulous maxillae without any alveolar reconstruction before or combined with implant placement	Prospective case series	Descriptive	Not reported	None declared	High

Table 14. Bias assessment of studies reporting the effects of implants placed in zygomatic bone with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
Yates et al. (2014-2013e)[58]	to analyse and report the 5-10-year survival rates of endosseous zygomatic implants used in the rehabilitation of the atrophic maxilla	Retrospective case series	FisherExact + Kaplan-Meier	Not reported	None declared	High
Aparicio et al. (2014-2012e)[59]	To report on long-term outcomes in the rehabilitation of the atrophic maxilla using zygomatic (ZI) and regular implants (RI).	Prospective case series	LifeTable	University of Barcelona EC	None declared	Medium
Fernandez et al. (2014)[60]	to describe the surgical techniques, success rate, prosthetic rehabilitation, complications, and demographics of patients undergoing zygomatic implant surgery.	Retrospective case series	Descriptive	"ERC guidelines of Universidad el Bosque"	None declared	High
Malo et al. (2013e)[61]	To report the outcome of rehabilitating 352 patients with complete edentulous atrophied maxillae using 747 zygomatic implants in immediate function inserted through the extramaxillary technique.	Retrospective case series	Kaplan-Meier	Ethics committee for health, Lisboa, 002/2012	None declared	High
Davo et al. (2013)[62]	to assess the long-term outcome of immediately loaded zygomatic implants placed in atrophic maxillae	Prospective case series	Descriptive	"The review board of the hospital"	None declared	High
Davo & Pons (2013)[63]	To assess the clinical 3-year outcome of prostheses supported by four immediately loaded zygomatic implants.	Prospective case series	Descriptive	Medimar Int. Hospital RB 3/2006	None declared	High
Malo et al. (2012)[64]	To report retrospectively on the 3-year follow-up results in the rehabilitation of completely edentulous atrophied maxillae using extra-maxillary zygomatic implants.	Retrospective case series	Friedman /Wilcoxon +LifeTable	Ethics committee for health, Lisboa, 003/2009	None declared	High
Migliorança et al. (2012)[65]	to evaluate the long-term success rate of immediate occlusal loading of extrasinus zygomatic implants after an 8-year follow-up.	Prospective case series	Descriptive	Not reported	None declared	High
Balshi et al. (2012)[66]	to view and measure the BIC of zygomatic implants in the zygomatic bone	Retrospective case series	LifeTable	Not reported	None declared	High
Aparicio et al. (2010-2008e)[67]	To report on the clinical outcomes of immediate early loading of zygomatic implants for prosthetic rehabilitation of edentulous and severely resorbed maxillary cases	Retrospective case series	LifeTable	Not reported	None declared	High
Aparicio et al. (2010-2008e)[68]	to report on the preliminary experiences with zygomatic implants placed with an extrasinus approach in order to have the implant head emerging at or near the top of the alveolar crest	Retrospective case series	No statistical tests	Not reported	None declared	High
Bedrossian (2010)[69]	to report on the 7-year follow-up of patients treated with zygomatic implants in conjunction with two to four anterior maxillary implants placed into immediate function and restored with a definitive fixed prosthesis.	Prospective case series	LifeTable	Not reported	None declared	High
Stievenart & Malevez (2010)[70]	To evaluates the results of a consecutive cohort of 20 patients (mean age 56 years) with extremely resorbed maxillas provided with four zygomatic implants.	Retrospective case series	LifeTable	Not reported	Nobel Biocare	High
Davo (2009)[71]	to evaluate the prosthetic rehabilitation success rate and the survival rates of machined surface zygomatic implants and conventional implants placed using a 2-stage protocol	Retrospective case series	No statistical tests	Not reported	None declared	High
Balshi et al.	To determine the clincal effectiveness of the zygomatic implant	Retrospectiv	LifeTable	Not	None	High

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
(2009)[72]	in oral implant reconstruction under an immediate loading protocol	e case series		reported	declared	
Pi Urgell et al. (2008)[73]	To evaluate the survival of 101 zygomatic implants placed in upper maxilla presenting important bone reabsorption, with a follow-up of 1-72 months.	Retrospectiv e case series	Descripti ve	Not reported	None declared	High
Davo et al. (2008a)[74]	to evaluate the success rate of immediately loaded zygomatic implants placed in atrophic maxillae	Retrospectiv e case series	No statistical tests	"The review board of the hospital"	Nobel Biocare research manager, Italy	High
Davo et al. (2008b)[75]	to evaluate the maxillary sinus in a cohort of patients by means of clinical criteria and computerised tomography performed before surgery and after zygomatic implant placement (immediate function protocol).	Prospective case series	No statistical tests	Not reported	Nobel Biocare research manager, Italy	High
Kahnberg et al. (2007)[76]	To evaluate the treatment outcome with zygoma implants with regard to implant survival, patient satisfaction, and function of prosthesis replacement after 3 years	Retrospectiv e case series	Descripti ve	Not reported	None declared (one coauthor is employe of Nobel Biocare AB, Sweden)	High
Duarte et al. (2007)[77]	to establish a new surgical/prosthetic protocol for the treatment of extremely atrophic maxillae using four zygomatic implants (ZIs) in an immediate loading system.	Prospective case series	Descripti ve	Not reported	None declared	High
Penarrocha et al. (2007)[78]	To describe the management of patients with extreme maxillary atrophy. Their treatment consisted of maxillary fixed prostheses supported by conventional implants placed in residual anatomic structures in conjunction with zygomatic implants positioned using the sinus slot technique of Stella and Warner	Retrospectiv e case series	Descripti ve (100% survival)	Not reported	None declared	High
Penarrocha et al. (2007)[79]	To evaluate the satisfaction of patients with maxillary fixed prostheses supported by conventional and or zygomatic implants	Retrospectiv e case series	t-test + Pearson Correl	Not reported	None declared	High
Bedrossian et al. (2006)[80]	To evaluate a protocol for immediate function (within 2 hours) of 2 zygomatic and 4 standard implants (Nobel Biocare) supporting a fixed prosthesis in the completely edentulous maxilla	Retrospectiv e case series	LifeTable	Not reported	None declared	High
Farzad et al. (2006)[81]	To describe the experiences of 11 consecutively treated patients who received zygomatic implants.	Retrospectiv e case series	Wilcoxon	Not reported	None declared	High
Ahlgren et al. (2006)[82]	To evaluate indications, surgical problems, complications, and treatment outcomes related to the placement of zygomatic implants. A second aim was to determine any prosthetic difficulties and complications	Retrospectiv e case series	No statistical tests	Not reported	None declared	High
Aparicio et al. (2006)[83]	To report on the clinical outcome of using zygomatic and regular implants for prosthetic rehabilitation of the severely atrophic edentulous maxilla.	Prospective case series	Descripti ve (100% survival)	Not reported	None declared	High
Becktor et al. (2005)[84]	To evaluate the clinical outcome of zygomatic implant treatment and consider if treatment with zygomatic implants could be an alternative to bone grafting and implant procedures in patients with edentulous maxillae	Retrospectiv e case series	No statistical tests	Not reported	None declared	High
Malevez et al. (2004)[85]	To evaluate retrospectively in consecutive patients, after a period of 6-48 months follow-up of prosthetic loading, the survival rate of 103 zygomatic implants inserted into 55 edentulous severely resorbed upper jaws	Retrospectiv e case series	Descripti ve (100% survival)	Not reported	None declared	High
Brånemark et al. (2004)[86]	To report the outcome of the first patients with a follow-up time of at least five years in whom zygoma fixtures were used in the treatment of the compromised edentulous maxilla and compared with bone grafting procedures	Prospective case series	Descripti ve	Not reported	Hilary Orton Memorial Foundation	High
Bedrossian	To present a preliminary report on 22 patients followed for 34	Prospective	Descripti	Not	None	High

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
et al. (2002)[87]	months who received the Branemark Zygomaticus implant in conjunction with premaxillary standard implants for the reconstruction of resorbed edentulous maxillae	case series	ve (100% survival)	reported	declared	

Table 15. Bias assessment of studies reporting the effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
Penarrocha-Oltra et al. (2013)[88]	To evaluate the 5-year outcome of a previously reported case series of patients with severely atrophic maxillae treated with palatally positioned implants and fixed full-arch rehabilitations	Retrospective case series	Descriptive	U Valencia Ethics Board H1330446292077	None declared	High
Balshi et al. (2013b)[89]	to determine if there is a statistically significant difference in the survival rates between different sized implants placed in the pterygomaxillary region.	Retrospective case series	LifeTable	Not reported	None declared	High
Balshi et al. (2013a)[90]	to determine if there is a significant difference in implant survival rates between implants in the pterygomaxillary region: implant placement with two-stage, single-stage, and guided surgery protocols.	Retrospective case series	LifeTable+MANOVA	Not reported	None declared	High
Rodriguez et al. (2012)[91]	To review a series of 454 pterygoid implants placed more vertically than the previous standard angle (45 degrees) over a functional loading period ranging from 2 months to 14 years with a mean follow-up period of 6 years	Retrospective case series	Descriptive	Not reported	None declared	High
Penarrocha et al. (2012)[92]	To assess the success and marginal bone loss, after 1 year of loading, of implants placed in anatomic buttresses of atrophic maxillae to rehabilitate patients with combination syndrome.	Retrospective case series	KruskalWallis/MannWhitneyU	Not reported	None declared	High
Penarrocha et al. (2009)[93]	To evaluate implant-supported restorations supported by palatally positioned implants as an alternative treatment for rehabilitation of the atrophic maxilla and to assess the satisfaction of patients with the results	Retrospective case series	Descriptive	Not reported	None declared	High
Penarrocha et al. (2009)[94]	to evaluate the success rate of implants placed in the pterygomaxillary region using drills and osteotomes with a minimum of 12 months' follow-up.	Retrospective case series	Descriptive	Not reported	None declared	High
Balshi et al. (2005a)[95]	To calculate the survival rate of Branemark implants with TiUnite surfaces in edentulous maxillary sites, including the pterygomaxillary region, restored with complete fixed maxillary prostheses	Retrospective case series	LifeTable	Not reported	None declared	High
Balshi et al. (1999)[96]	to examine all patients whose dentition had been restored with a complete maxillary prosthesis supported by Branemark implants in pterygomaxillary sites and to address the biomechanical aspects of implant size, position and bone quality with patient age, gender, smoking habits and medications	Retrospective case series	Descriptive	Not reported	None declared	High

Table 16. Bias assessment of studies designed to report effects of bone augmentation with simultaneous or delayed implant placement reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
Zinser et al. (2013-2012e)[97]	To assess the predictors of implant failure after grafted maxillary sinus (GMS).	Retrospective case series	Kaplan-Meier+CoxRegression	Not reported	None declared	High
Dasmah et al. (2013-2011e)[98]	to conduct a 5-year follow-up analysis with focus on bone-level alteration in block versus particulate onlay bone grafts	CCT Prospective study w/ concurrent controls- Split (Block vs particulate+prp onlay)	Wilcoxon	Not reported	None declared	High
Sjöström et al. (2007)[99]	To conduct a 3-year follow-up with respect to clinical, radiological, and RFA parameters of implant stability in 29 patients with atrophic edentulous maxillae reconstructed with free autogenous iliac bone graft and titanium implants	Prospective case series	LifeTable+LogisticRegression (ISQ: MannWhitney / SpearmanRho)	"The local REC"	None declared	Medium
Chiapasco et al. (2007)[100]	To report the clinical outcome of osseointegrated implants placed in extremely atrophied edentulous maxillae after Le Fort I osteotomy and interpostional autogenous iliac bone gradts	Prospective case series	LifeTable	Not reported	None declared	High
Hallman et al. (2005)[101]	To compare two different implant systems used after interpositional bone grafting of the severely resorbed maxilla with a modified augmentation technique using fibrin glue	CCT Prospective study (Astra) w/ historical controls (Brånemark)	Chi²/MannWhitneyU	Not reported	None declared	High
Becktor et al. (2004)[102]	To analyze and compare the survival rates of endosseous implants placed in the edentulous maxillae of patients in whom bone aygmentation was undertaken prior to or in conjunction with implant placement with survival rates in patients who did not undergo bone augemantation	Retrospective case series	Chi²/Wilcoxon+LifeTable	Not reported	None declared	High
Pinholt (2003)[103]	To observe the clinical outcome of Brånemark machine-surfaced implants in a comparative evaluation with ITI SLA implants inserted into severely atrophied maxillae reconstructed with autogenous bone graft	CCT Prospective study (Straumann) w/ historical controls (Brånemark)	Descriptive	Not reported	None declared	High
Becktor et al. (2002)[104]	To analyze the influence of the mandibular dentition on implant performance in the maxilla prior to definitive prosthesis attachment when reconstruction is possible only with the use of autogenous bone-grafting techniques	Retrospective study w/ concurrent controls	LogisticRegression+GeneralEstimationEquation(GEE)	Not reported	None declared	Medium
Lekholm et al. (1999)[105]	To study the extent to which different bone grafting procedures are performed ii) evaluate the treatment results obtained after three years of function and iii) assess possible complications occuring during treatment and follow-up	Retrospective case series	Descriptive	Not reported	None declared	High
Keller et al. (1999)[106]	To present a retrospective study of patients with advanced horizontal and vertical bone loss and complete or partial edentulism who were treated with an autogenous rigidly-fixed block onlay bone graft	Retrospective case series	Descriptive	Not reported	None declared	High
Keller et al. (1999)[107]	To present a continuation of a study of medical, surgical and prosthetic records of patients with advanced maxillary bone resorption in whom autogenous inlay bone grafts were placed in the maxillary antrum or nasal floor.	Retrospective case series	Descriptive	Not reported	None declared	High
Watzek et	To examine whether the concept of sinus floor	Retrospective	ANOVA+Kap	Not	None	High

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
al. (1998)[108]	augmentation can also be recommended in the treatment of patients with extreme maxillary resorption and, second, whether the concept of placing implants mainly in maxillary posterior regions is suitable for this group of patients	study w/ concurrent controls	lan-Meier+LogRank	reported	declared	
Nyström et al. (1997)[109]	To present the results from ten consecutive patients who, because of insufficient bone volume for conventional implant placement in the maxilla, were treated with an interpositional bone graft and Le Fort I osteotomy	Retrospective case series	Descriptive	Not reported	None declared	High
Köndell et al. (1996)[110]	To evaluate the treatment of patients with severely resorbed edentulous maxillae with immediate autogenous rib grafts and titanium implants in a one-stage procedure with the onlay technique	Prospective case series	Descriptive	Not reported	None declared	High
Neukam (1996)[111]	To report a retrospective study of 43 patients with extreme severe maxillary ridge resorption who had received only grafts from the iliac crest with simultaneous placement of osseointegrated implants.	Retrospective case series	Kaplan-Meier+LogRank+CoxRegression	Not reported	None declared	Medium
Keller et al. (1994)[112]	To describe a one-stage antral and nasal inlay composite bone-grafting procedure and to present preliminary statistical data for 30 recipient sites in 20 patients	Prospective case series	Descriptive	Not reported	None declared	High

Table 17. Bias assessment of studies designed with no *a priori* stated objective to assess a particular implant design feature

Lead author	Study objective	Study design	statistics	REB	Funding	Risk of bias
Jemt et al. (2011)[113]	to report and compare the treatment outcomes of two patient cohorts from the same clinic, rehabilitated with fixed implant prostheses in the edentulous maxilla between 1986 and 1987 (early) and 2001 to 2004 (late).	Retrospective study w/ historical controls	Chi²/t-test+Life Table	Not reported	None declared	High
Friberg & Jemt (2008-2007e)[114]	to retrospectively evaluate and compare the outcome of implants placed in edentulous maxillae with either wide or narrow jaw shapes. The marginal bone loss and implant cumulative survival rates (CSRs) were calculated and analyzed with special reference to smoking habits.	Retrospective case series	Chi²/t-test+FisherPermutation+Life Table	Not reported	None declared	High
Jemt & Johansson (2006)[115]	to report 15-year patient-based data in relation to time of follow up after treatment with fixed prostheses supported by implants in the edentulous upper jaw.	Prospective case series	Chi²/t-test+Life Table	Not reported	None declared	High
Widbom et al. (2005)[116]	To retroactively evaluate outcome in two groups of patients treated with implant-supported maxillary overdentures. Various factors related to the treatment were compared among subjects in the two groups	Retrospective case series	LifeTable +CoxRegression	Not reported	None declared	High
Ibanez et al. (2005)[117]	To determine whether, with proper care selection and adherence to established principles, immediate occlusal loading of double acid-etched surface implants could be considered for clinical use in both arches after strict evaluation and longer follow-up	Prospective case series	Descriptive	Not reported	None declared	High
Degidi & Piattelli (2003)[118]	To evaluate clinically implants subjected to immediate functional loading (IFL) and to immediate non-functional loading (INFL) in various anatomical configurations	Retrospective case series	LifeTable	Not reported	Apollonia, Italy & Biohorizons, USA & Friadent, Germany & Lifecore, USA & Nobel Biocare, Sweden	High
Kiener et al. (2001)[119]	To report on prosthetic complications and maintenance of maxillary overdentures supported by ITI implants	Retrospective case series	Kaplan-Meier	Not reported	None declared	High
Watson et al. (1998)[120]	To evaluate the long-term effectiveness of Calcitek cylindrical HA-coated implants to support maxillary or mandibular overdentures; (2) to compare the maxillary and mandibular success and survival rates of implants and prostheses; (3) to report on the maintenance requirements associated with overdenture treatment with this system	Prospective case series	LifeTable	Not reported	Calcitek Corp., USA & Leeds General Infirmary Trust, U.K.	High
Jemt & Lekholm (1995)[121]	To compare the 5-year treatment result of the Branemark implant technique, when used in different maxillary shape situations and when using various prosthetic solutions, to determine if the outcome is predictable based on the presurgical jaw shape assessment	Retrospective case series	t-test+Life Table+CoxRegression	Not reported	Nobelpharma AB, Sweden	High
Palmqvist et al. (1994)[122]	To retrospectively compare the outcomes of implant-supported maxillary overdentures in planned and emergency cases	Retrospective case series	Kaplan-Meier+LogisticRegression	Not reported	None declared	High

Table 18. Results of studies designed with an objective to assess effects of implant design or -feature on outcomes

Lead author	Pre-surgery	Surgery details	Post-surgery	Prosthesis	Outcome	Patient-outcome	FINDINGS
Jungner et al. (2014-2012e)[18]	Healed. No grafting	2 protocols: If stable then 1-stage(32p 59i), otherwise 2-stage(57p 174i)	2 protocols: 1: If stable ant. mandible then loading 13-32days(14p 54i) 2: Healing 4-36 (av.17) weeks.	Crown(36i) pFDP(103i) fullFDP(148i)	PAXBone Perioindice Removed implant.	Not reported	Surface influence the outcome. Oxidized marginally better than turned.
Vervaeke et al. (2013e)[19]	No periodontitis	"according to manufacturers guidelines" 2 protocols: 1/2-stage	2 protocols: 1: If good stability, immediate impression. Temp pmma+metal < 24h. -> >3 months perm. 2: Healing	Crown pFDP fFDP	PA/OPXBone SuccSurv	Not reported	Multivariate analyses indicated no effect of implant length, diameter or design on survival or bone loss
Testori et al. (2013e)[20]	2 protocols: 1. Healed 2: Postextraction	Ab. 2 protocols: 1/2-stage	2 protocols: 1: Stability > 32Ncm, immediate impression, tempFDP < 48h; otherwise, Healing 2-6 months,	4-8i-FDP-cem/screw	Adverse* PAXBone SuccSurv	Not reported	The multivariate analyses indicated no effect of implant length, diameter or design on survival or bone loss, contrasting the univariate estimates
Ravald et al. (2013)[21]	Healed 3-6 months	2-stage	Healing 4mand./6.5max. Months	5/6i-ga/TiA/mc-10/12u-FDP-screw	Adverse* PAXBone Perioindices	Not reported	Implant system does not influence outcome. (Corrects somewhat earlier data of same cohort by Engquist ea. 2002 & Åstrand ea. 1999 & 2004).
Van Assche et al. (2012-2011e)[22]	Healed 6 months	Ab. Distal sites underprepared. 15+ NCm	Healing 6+ weeks, bar+denture -> 6 months egg-shaped-bar-newCoCr	4i+2post.short-egg-shape-bar-CoCr-overdenture	Adverse PAXBone Perioindices Stability-ptv/RFA SuccSurv(Buserea90)	Not reported	Multivariate analyses indicated that implant length does not influence outcome. No differences were noted between the two short posterior implants versus the other implants supporting the FDP
Cosyn et al. (2012-2010e)[23]	3 protocols: 1: Postextraction (6%) or within 6 weeks (7%) 2: Healed (87%). No periodontitis. 3: Augmented-onlay/inlay (18%)	2 protocols: 1(43%)/2(57%) -stage	2 protocols: 1: Immediate	Crown pFDP fFDP Overdenture	PA/OPXBone SuccSurv	Not reported	Multivariate analyses indicated no effect of implant length or diameter on outcome. Surfaces/systems not compared.
Kallus et al. (2009-2008e)[24]	Healed 6 months	Not reported	Healing 4mand./6max. Months	6i-FDP-ns	PAXBone SuccSurv	Not reported	Implant system does not influence outcome.
Li et al. (2009)[25]	2 protocols: 1. Healed 2: Postextraction	Ab. "standard protocol". 20-50 NCm	Immediate abutment. Pmma FDP -->	4/6i-FDP	OPXBone SuccSurv	Not reported	No differences noted between designs lengths and diameter
Alsaadi et al. (2008b)[26]	Not reported	Not reported	Not reported	Crown pFDP fFDP	PAXBone Stability-ptv SuccSurv	Not reported	Multivariate analyses indicated more bone loss around ø5mm than others. Trend for more loss with machined surfaces. No

Lead author	Pre-surgery	Surgery details	Post-surgery	Prosthesis	Outcome	Patient-outcome	FINDINGS
							effect of length.
Nelson et al. (2008)[27]	Some augmented. Some healed	Not-Ab. GA/La. Flap. 1-stage	Immediate reline --> 6md/12mx weeks. If >35Ncm then rehabil.	FDP Overdenture	Adverse OPGXbone Perioindices SuccSurv(Buserea02)	Not reported	Implant design does not influence outcome. (No implants were lost following the abutment connection)
Malo et al. (2007)[28]	Not reported	Ab. La. Flap. Ø-undercontour, 0.8mm-supra, 32+NCm	Immediate final abutment. 2 protocols: 1. immediate (16p/23i) 2: Healing 4-6 months	Crown(58) pFDP(296i) totalFDP(54i)	Adverse* PAXBone SuccSurv	Not reported	Implant surface influence outcome. All the failed implants (n=13) were turned and not microrough. Possible learning curve effect. Concurrent use of short and long implants to support FDP.
Hjalmarsson & Smedberg (2005)[29]	Not reported	Not reported	Not reported	4/8i-Au/Ti-FDP-screw(24p) OR 4/8i-Au/Ti-FDP-cresco(26p)	Adverse* Bone Perioindices Preload	Satisfaction-VAS	No difference noted between two implant systems
Degidi et al. (2005)[30]	2 protocols: 1: Postextract (23p, 175i) 2: Healed (20p, 213i)	Ab. La. Flap. Max Ant./Post. Spread	Immediate pmma-FDP --> 4-6months permanent	6-12i-12u-mcFDP-cement	PAXBone SuccSurv	Not reported	Multivariate analyses indicated that implant diameter influenced outcome. Implants with diameter more than 5.25 mm had a hazard rate of x3.1 compared to <5.25mm
Schwartz-Arad et al. (2004)[31]	2 protocols: 1: Postextract (144i) 2: Healed(237i)	Ab. Maximal implant lengths. 2-stage.	Immediate soft-reline --> healing time n.r.	mc-FDP	OPXBone	Not reported	Multivariate analyses indicated that implant length does not influence bone loss. Implant coating may have a marginal effect on outcome.
Morris et al. (2001)[32]	Not reported	Ab.	Not reported	Crown/FDP 5-6i-ball/bar-overdenture	PA/OPXBone Perioindices Stability-ptv Succsurv(DICRG92)	Not reported	Implant surface may influence outcome. cpTitanium screw have worse outcomes compared to hydroxyapatite screw and cylinders
Friberg et al. (1997)[33]	Healed 3-4mths	2-stage	Healing 6 months	ga-FDP-screw	PAXBone	Not reported	No difference between two designs, one with and one without tapping
Olsson et al. (1995)[34]	Healed 6 months	1exp.+1ctr implant in each contralateral quadrant. 2-stage	Healing 4md/6mx months	4-6i-FDP	1: SurgCompl ic/Success 2: 2: Adverse* PAXBone	Not reported	Implant design does not influence outcome

Surgery: Ab.= antibiotics; GA / La = general / local anesthesia;
Prosthesis: mc= metal ceramic/ac=all ceramic/ga=gold-acrylic; CoCr=cobolt-chrome; u=unit;
Outcome: PAX / OPX = Periapical / Panoramic radiographs; SuccSurv= clinical success or survival;
Stability-ptv/rfa=Periotest/Radio-frequency analysis

Table 19. Results of studies reporting the effects of tilted implants to enable placement of longer implants

Lead author	Pre-surgery	Surgery details	Post-surgery	Prosthesis	Outcome	Patient-outcome	FINDINGS
Agliardi et al. (2014-2012e)[35]	2 protocols: 1: Postextraction-pal+autograft (2) Healed	Ab. La. Flap. Post.tilt 30-45°, medial i.tilt 30-45°, axial. Underprepared; 30+ Ncm	Immediate permanent abutment. Suture. Impression, pmma-FDP 4-6mths-> permanent	4tilt+2i-cadcamTiA-12u-FDP-Procera	Adverse* PAXbone Perioindices SuccSurv(vSteenb)	Satisfaction-5-Likert	Tilted : axial implants performance comparable. The effects of different implant systems were not reported
Agnini et al. (2014-2012e)[36]	2 protocols: 1: Postextraction autograft+allograft-no membrane (2) Healed	Ab. La. Flap. 2 protocols: 1: If 9mm bone then 6-8 axial imp 2: If	Immediate impression. Healing abutment. Suture. Pmma-FDP 6 months-> permanent	2tilt+2i/6-8i-mc/ac/Tia-FDP /CAD-ZrO/TiO-FDP	Adverse* PAXbone	Not reported	Tilted : axial implants performance comparable for one system, but worse for tilted when alternative system described. Could be an effect of unbalanced intraoral distribution / restorations.
Pera et al. (2014)[37]	Postextraction	Underprepared, posterior angled if required. >40NCm	Immediate abutmenr+impression -> pmma within 36h -> 4 months healing	4-6-FDP-screw	PAXBone	Not reported	Tilted : axial implants performance comparable. Multivariate stats indicated that roughness of implant neck does not influence outcome.
Pozzi et al. (2013e)[38]	2 protocols: 1: Postextraction(44i) (2) Healed (126i)	n.r., 30Ncm, Peri-implant autograft	Immediate prefabricated pmma w/metal screws -> 3-4 mths -> permanent	2tilt+2-8i-CAD-ZrOFDP	Adverse* OPGXBone Perioindices SuccSurv(vSteenb)	Satisfaction-VAS	Implant system does not influence outcome. No implants were lost. (However only 2 versus 10 patients had implants in the edentulous maxilla)
Malo et al. (2013)[39]	Healed	Ab. La. Flap. Fenestration. TransSinus, Post.tilt. <45°, 32+ NCm	Immediate impression, pmma screws 6mths --> permanent	2tilt+2i-12u-FDP	Adverse* OPG/PAXBone SuccSurv	"Complaints"	The axial implants performed slightly better than the tilted
Testori et al. (2013)[40]	Not reported	Ab. La. Flap. Fenestration, TransSinus, Post.tilt. <30°, Xenograft	Healing 6 months-> permanent	2tilt+2/4i-12u-TiaFDP-screw	Adverse* PAXBone SuccSurv	Satisfaction-4-Likert	Tilted : axial implants performance comparable.
Di et al. (2013)[41]	2 protocols: 1: Postextraction 2; Healed	Ab. La. Flap. Fenestration, Post.tilt. <45°, 35 NCm	Immediate impression, pmma screws 6mths --> permanent	2tilt+2i-12u-gaFDP	Adverse* OPGXBone SuccSurv	Satisfaction-5-Likert	Tilted : axial implants performance comparable.
Malo et al. (2012-2011e)[42]	2 protocols: 1: Postextraction 2; Healed	Ab. La. Flap. Fenestration. Post.tilt. 35-45°, Underprepared. 35+ NCm	Immediate impression, pmma screws 6mths --> permanent	2tilt+2i-TiC-FDP-Procera /TiA-FDP	Adverse* OPG/PAXBone SuccSurv	"Complaints"	Tilted : axial implants performance comparable. Implant design influence outcome. One implant system had higher failure rate than the others.
Francetti et al.	2 protocols: 1:	La. Flap. Fenestration. Post.tilt. 30°. 40-50	2 protocols: (1) If>40-50NCm	2tilt+2i-12u-mcFDP-	Adverse* PAXBone	Not reported	Tilted : axial implants performance

Lead author	Pre-surgery	Surgery details	Post-surgery	Prosthesis	Outcome	Patient-outcome	FINDINGS
(2012-2010e)[43]	Postextraction 2; Healed	NCm	then immediate abutment(straight/30°multiunit)+Pickup pvs-impression.pmma-FDP 4- 6 mths permanent	Procera-screw	SuccSurv		comparable.
Mozzati et al. (2012)[44]	2 protocols: 1: Postextract (210i) (2) Healed (124i)	Ab. La. Bone remodel. Flap. Post.tilt. 30°, "Nanocrystalline paste"(35p,108i). 40 NCm	Immediate pmma-screw -> 6+ mhts healing-> permanent	2tilt+2/4i-mcFDP	Adverse* PAXBone Perioindices SuccSurv(Albrekt)	Satisfaction-Y/N	Tilted : axial implants performance comparable.
Crespi et al. (2012)[45]	2 protocols: 1: Postextraction 2; Healed	Ab. La. Flap. Post.tilt-25-35° (4mm-13/15mm), axial (3.75/4mm-13mm). Underprepared.	2 protocols: 1: If >40 Ncm then immediate abutment(17/30°)+pickup pre-impression+bite-registration. prefab pmma+/-metal-FDP+ -->	2tilt+2i-10/12u-ga-FDP-screw	Adverse* PAXBone SuccSurv	Not reported	The axial implants performed slightly better than the tilted
Cavalli et al. (2012)[46]	2 protocols: 1: Postextraction 2; Healed	Ab. La. Flap. Post.tilt-30°. 40-50 NCm	Immediate permanent abutment. Suture. Impression, pmma-FDP 6mths-> permanent	2tilt+2i-12u-CAD-TiA-FDP-Procera	Adverse* PAXBone Perioindice SuccSurv	Not reported	Implant system does not influence outcome. No implants were lost
Malo et al. (2012)[47]	2 protocols: 1: Postextraction 2; Healed	Ab. La. Flap. Fenestration. Post.tilt. 35-45°, Underprepared. 35+ NCm	Immediate impression, pmma screws 6mths --> permanent	2tilt+2i-TiC-FDP-Procera/TiA-FDP	Adverse* OPG/PAXBone SuccSurv	"Complaints"	Tilted : axial implants performance comparable. Implant system does not influence outcome.
Malo et al. (2011)[48]	2 protocols: 1: Postextraction 2; Healed	Ab. La. Flap. Fenestration. Post.tilt. 35-45°, Underprepared. 35+ NCm	Immediate impression, pmma screws 6mths --> permanent	2tilt+2i-TiC-FDP-Procera/TiA-FDP	Adverse* OPG/PAXBone SuccSurv	"Complaints"	Tilted : axial implants performance comparable. Multivariate stats indicated that implant system does not influence outcome.
Agliardi et al. (2010)[49]	Healed	Ab. La. Flap. Post.tilt. 30-45°, Underprepared. 30+ NCm	Immediate permanent abutment. Suture. Impression, pmma-FDP 4-6mths-> permanent	2tilt+2i-cadcamTiA-FDP-canti-Procera	Adverse* PAXbone Perioindices	Not reported	Tilted : axial implants performance comparable. The effects of different implant systems were not reported
Degidi et al. (2010)[50]	Healed	Ab. La. Flap. Post.tilt-30-45°. No bone grafting. Minimum 25NCm/ISQ60 for study inclusion	Immediate abutment. Prefabricated pmma FDP. Welded framework, o2mm bar. Removed&Sandblasted. Permanent.	4tilt+3i-10/12u-weld-bar-gaFDP-screw	Adverse* PAXBone Perioindices SuccSurv	Not reported	The tilted implants performed slightly better than the axial
Pomares (2009)[51]	2 protocols: 1:	La. La. MaloSurgGuide. If poor bone 6 implants,	Immediate abutment.+impre	2tilt+2i-cadcamTiA-	Adverse* OPG/PAXBo	Not reported	Tilted : axial implants performance

Lead author	Pre-surgery	Surgery details	Post-surgery	Prosthesis	Outcome	Patient-outcome	FINDINGS
	Postextraction 2; Healed	otherwise 4.	ssion -> temp pmma > 7 days -> Healing 5-15 months -> permanent	FDP-canti-Procera	ne SuccSurv		comparable.
Agliardi et al. (2009)[52]	2 protocols: 1: Postextraction(40i) 2: Healed (80i)	Ab. La. Flap. Post.tilt 30-45°, medial i.tilt 30-45°, axial. Underprepared; 30+ Ncm	Immediate permanent abutment. Suture. Impression, pmma-FDP 4-6mths-> permanent	4tilt+2i-10/12u-cadcamTiA-12u-FDP-Procera	Adverse* PAXbone Perioindices SuccSurv	Satisfaction-5-Likert	Implant system does not influence outcome. No implants were lost
Rosen & Gynther (2007)[53]	Not reported	NoAb. La. Fenestration. Post.tilt. >30°, if thin, palatal w/2-5exposed threads. No graft. No membrane. 2-stage	Healing 6 months-> permanent	2tilt+4i-12u-cocr/AgPd/TiaFDP-canti-screw	Adverse* OPG/PAXBone Perioindices SuccSurv(Albrekt)	Satisfaction-Y/N	Tilted : axial implants performance comparable.
Capelli et al. (2007)[54]	Healed	Ab. La. Flap. Fenestration. Post.tilt-25-35°, 1-stage crestal/subcrestal	2 protocols: 1: If>30+ NCm then immediate pmma-FDP 3months permanent	2tilt+2/4i-12u-TiA-FDP-screw	Adverse* PAXbone SuccSurv(Albrekt86)	Satisfaction-Y/N?	Tilted : axial implants performance comparable.
Fortin et al. (2002)[55]	Healed	30+ NCm	Healing 3/6 months-> permanent	2tilt+1-5i-bar-Marius bridge	Adverse* SuccSurv(vSteenb)	Satisfaction-Y/N	Tilted : axial implants performance comparable.
Krekmanov et al. (2000)[56]	Healed	Ab. La. Flap. Fenestration. Post.tilt-30-35°, anterior-tilt varies	Healing 3/6 months-> permanent	6tilt-Ga/TiA-FDP	Adverse* BiteForce SuccSurv(Albrekt)	Not reported	The tilted implants performed slightly better than the axial
Mattsson et al. (1999)[57]	Not reported	NoAb. La. Fenestration. Post.tilt. >30°, if thin, palatal w/2-5exposed threads. No graft. No membrane. 2-stage	Healing 6 months-> permanent	2tilt+4i-12u-cocr/AgPd/TiaFDP-canti-screw	Adverse* SuccSurv(Albrekt)	Not reported	Tilted : axial implants performance comparable.

Surgery: Ab.= antibiotics; GA / La = general / local anesthesia;
Prosthesis: mc= metal ceramic/ac=all ceramic/ga=gold-acrylic; CoCr=cobolt-chrome; u=unit;
Outcome: PAX / OPX = Periapical / Panoramic radiographs; SuccSurv= clinical success or survival

Table 20. Results of studies reporting the effects of implants placed in zygomatic bone with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_ Patient	Findings
Yates et al. (2014-2013e)[58]	Healed	GA. SinusSlot. Suture. 2-stage	Healing 6 months	2-4i+1/2zyg-FDP-screw Overdenture	SuccSurv(Buser)	Not reported	
Aparicio et al. (2014-2012e)[59]	Healed	Ab. GA. Flap. vertical rectangular sinuswindow, TransSinus implant, 2-stage	Healing 5-6 months	2-5i+2zyg-FDP-cem(3)/screw(19)	Adverse* Stability_ptb SuccSurv	Sinusitis-Y/N OHIP-Edent	
Fernandez et al. (2014)[60]	Healed	Ab. GA. Flap. 2 protocols: 1. vertical rectangular sinuswindow, TransSinus implant (51p) 2: No winwow (29p)2-stage	Not reported	Not reported	Adverse* SuccSurv	Not reported	
Malo et al. (2013e)[61]	Not reported	Ab. GA/La Flap. 3 protocols? XtraMaxillary. ≥ 30NCm	Immediate impression, pmma screws same day -> 6mths --> permanent	1-4i+2/4zyg-FDP	Adverse* SuccSurv	Not reported	
Davo et al. (2013)[62]	Healed Postextraction	Ab. GA. Flap. 3 protocols: 1: vertical rectangular sinuswindow,TransSinus implant (66i) 2: SinusSlot (15i) 3: "minimal invasive" SinusSlotXtraSinus	Immediate impression, metal-reinforced pmma 24-48 hours --> Healing 6 months	2-6i+2/4zyg-FDP-screw	Adverse* SuccSurv	Not reported	Performance of different conventional implants and turned versus oxidized zygoma implants not reported
Davo & Pons (2013)[63]	Healed	Ab. GA. Flap., vertical rectangular sinuswindow, TransSinus implant, >35NCm. Suture.	Immediate impression, metal-reinforced pmma 24-48 hours --> Healing 6 months	4Zyg-FDP-screw(15p) Overdenture(2p)	Adverse* SuccSurv	OHIP-14	
Malo et al. (2012)[64]	Healed	Ab. GA(32p) La(7p) Flap. XtraMaxillary. ≥ 30NCm	Immediate pmma temp same day. --> 6 months	1-4i+2/4zyg-Tia/ga-FDP	Adverse* PAXBone Perioindices SuccSurv	Not reported	Performance of different prototype zygoma implants not reported
Miglioranca et al. (2012)[65]	Healed	Ab. GA+La. Flap. XtraSinus. ≥ 35NCm. Abutment. Suture	2 protocols: 1. If > 40 NCm then immediate impression, temp pmma 6 months 2: Healing 6 months	2-4i+2zyg-10u-FDP-screw	Adverse* SuccSurv	Not reported	
Balshi et al. (2012)[66]	Healed	Ab. GA. Flap., vertical rectangular sinuswindow, PrP-prep.+ TransSinus implant	Immediate autopolymer pmma in denture < 2h--> 3 months	2-4i+2zyg+2pter-ga/mcFDP	Adverse* CAD-BIC SuccSurv	Not reported	Performance of turned versus oxidized zygoma implants not reported
Aparicio et al. (2010-2008e)[67]	Healed	Ab. GA. Flap. 2 protocols: 1: vertical rectangular sinuswindow,TransSinus implant (7p) 2: XtraSinus (18p)	2 protocols: 1: Immediate temp pmma < 24h --> 4-6 months 2: Immediate impression, suturing, denture relief. Submerged healing 6 months. permanent FDP < 5	2-5i+2zyg-mcFDP	Adverse* SuccSurv	Not reported	

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_ Patient	Findings
			days				
Aparicio et al. (2010-2008e)[68]	Healed	Ab. GA. Flap. XtraSinus	Immediate impression, suturing, denture relief 2 protocols: 1: Immediate temp pmma < 24h --> 4-6 months 2: permanent FDP < 5 days	3-4i+2zyg-FDP	Adverse* SuccSurv	Not reported	
Bedrossian (2010)[69]	Healed	Ab. GA+La. Flap., vertical rectangular sinuswindow, TransSinus implant	Immediate autopolymer pmma in denture -> 6 months premanent	2-4i+2zyg-FDP	Adverse* SuccSurv	Not reported	Performance of different conventional implants not reported
Stievenart & Malevez (2010)[70]	Healed	Ab. GA+La. Flap., vertical rectangular sinuswindow, TransSinus implant. 2 protocols: 1: 2-stage(10p) 2: 1-stage(10p)+immediate/earlyload	2 protocols: 1: Healing 2-5 months 2: immediate temp pmma < 1-14d	4zyg-Tia-FDP-Procera	Adverse* SuccSurv	Not reported	
Davo (2009)[71]	Healed Postextraction	Ab. GA. Flap. vertical rectangular sinuswindow, TransSinus implant, 2-stage	Healing 6 months	3-6i+2zyg-ga-FDP-screw(19p) Overdenture(3p)	Adverse* SuccSurv	Not reported	Performance of turned versus oxidized conventional implants not described
Balshi et al. (2009)[72]	Healed	Ab. GA. Flap., vertical rectangular sinuswindow, PrP-prep.+ TransSinus implant	Immediate autopolymer pmma in denture < 2h--> 3 months	2-6i+2zyg+2pter-ga/mcFDP	Adverse* SuccSurv	Not reported	Performance of turned versus oxidized zygoma implants not reported
Pi Urgell et al. (2008)[73]	Healed	Ab. GA+La. Flap. SinusSlot. Suture. 2 stage	Healing 6-12 months	4i+2zyg-FDP/Overdenture	Adverse* SuccSurv	Not reported	
Davo et al. (2008a)[74]	Healed Postextraction	Ab. GA. Flap. 3 protocols: 1: vertical rectangular sinuswindow,TransSinus implant (66i) 2: SinusSlot (15i) 3: "minimal invasive" SinusSlotXtraSinus	Immediate impression, metal-reinforced pmma 24-48 hours --> Healing 6 months	2-6i+2/4zyg-FDP-screw	Adverse* SuccSurv	Not reported	Performance of different conventional implants and turned versus oxidized zygoma implants not reported
Davo et al. (2008b)[75]	Healed Postextraction	Ab. GA. Flap. 2 protocols: 1: vertical rectangular sinuswindow,TransSinus implant (61i) 2: SinusSlot (10i)	Immediate impression, metal-reinforced pmma 24-48 hours --> Healing 6 months	2-6i+1/2/4zyg-FDP-screw	Adverse* SuccSurv	Not reported	Performance of turned versus oxidized zygoma implants not reported
Kahnberg et al. (2007)[76]	Healed	Ab. GA. Flap. Autograft+ vertical rectangular sinuswindow,TransSinus implant, 2-stage	Healing 6 months	2-4i+2zyg-FDP/Overdenture	Adverse* SuccSurv	Satisfaction	
Duarte et al. (2007)[77]	Healed	Ab. GA. Flap., vertical rectangular sinuswindow, TransSinus implant	Immediate abutment. Autopolymer surgeryguide. Impression. Permanent next day.	4zyg-ga-FDP-screw	Adverse* SuccSurv	Not reported	
Penarroc	Healed	Ab. GA+La. Flap.	Healing 2 months	3-6i+1/2zyg-	Adverse*	Not	Performance of

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_ Patient	Findings
ha et al. (2007)[78]		SinusSlot. Suture. 2 stage		FDP-screw/cem	SuccSurv	reported	different conventional implants not reported
Penarrocha et al. (2007)[79]	Healed	Ab. GA+La. Flap. 2 Protocols: 1. conventional imp. 2-stage(23p) 2: conventional+SinusSlot(23p). 2 stage	Healing 2 months	3-6i+1/2zyg-FDP-screw/cem	Adverse* SuccSurv	Satisfaction-VAS	Performance of different conventional implants not reported
Bedrossian et al. (2006)[80]	Healed 12m+	Ab. GA+La. Flap., vertical rectangular sinuswindow, TransSinus implant, 40NCm	Immediate autopolymer pmma in denture -> 6 months premanent	2-4i+2zyg-FDP	Adverse* SuccSurv	Satisfaction	
Farzad et al. (2006)[81]	Healed	Ab. GA. Flap. vertical rectangular sinuswindow,TransSinus implant, Immediate impression, suturing, denture relief	Healing 6 -11 months	2-4i+2Zyg-Tia-FDP-Procera	Adverse* Stability-RFA SuccSurv	Satisfaction-VAS	
Ahlgren et al. (2006)[82]	Failed implant surgery / Cleft-palate / Grafting-refusal	Ab. GA. Flap., Onlay graft (2p), vertical rectangular sinuswindow, TransSinus implant, 2-stage	Healing 5-6 months	2-5i+2zyg-FDP/Overdenture	Adverse* SuccSurv	Not reported	Performance of turned versus oxidized conventional implants not described
Aparicio et al. (2006)[83]	Healed	Ab. GA. Flap., vertical rectangular sinuswindow, TransSinus implant, 2-stage	Healing 5-6 months	2-4i+2/4zyg-ga-FDP-cem	Adverse* Stability_ptb SuccSurv	Not reported	
Becktor et al. (2005)[84]	Healed	Ab. GA. Flap. vertical rectangular sinuswindow, TransSinus implant, 2-stage	Healing 5-8 months	1-6i+2zyg-gaFDP	Adverse* SuccSurv	Not reported	Performance of different conventional implants not reported
Malevez et al. (2004)[85]	Healed (Graft (n=7)->4-6m)	Ab. GA. Flap. vertical rectangular sinuswindow, TransSinus implant, 2-stage	Healing 6 months	2-4i+2zyg-FDP	Adverse* Perioindices SuccSurv	Not reported	
Brånemark et al. (2004)[86]	Healed	Ab. GA. Flap. Autograft(17p) vertical rectangular sinuswindow,TransSinus implant	Immediate impression, suturing. Healing 6 months	2-5i+1-4zyg-FDP-screw	Adverse* SuccSurv	Not reported	
Bedrossian et al. (2002)[87]	Healed	Ab. GA+La. Flap., vertical rectangular sinuswindow, TransSinus implant,	Immediate impression, suturing, denture relief. Healing 6 months	2-4i+2zyg-ma/ga-FDP	Adverse* SuccSurv	Not reported	

Surgery: Ab.= antibiotics; GA / La = general / local anesthesia;
Prosthesis: mc= metal ceramic/ac=all ceramic/ga=gold-acrylic; CoCr=cobolt-chrome; u=unit;
Outcome: PAX / OPX = Periapical / Panoramic radiographs; SuccSurv= clinical success or survival

Table 21. Results of studies reporting the effects of implants placed in pterygoid bone or other bony buttresses with or without additional alveolar implants reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	AO2014
Penarrocha-Oltra et al. (2013)[88]	Healed	La. Flap. ≥4 imp. placed tilted & palatal w/ 2-5 exposed threads covered w/ autograft+Xenograft. 2 stage.	Healing 2+1-2 months	6-8i-mcFDP-cem /ga-FDP-screw / 2tilt+2i-bar-Overdenture	Adverse* OPGXbone Perioindices	OHIP-14 Satisfaction-VAS	(Long) tilted and palatally placed versus conventional implant comparable outcomes
Balshi et al. (2013b)[89]	Not reported	Not reported	Not reported	Not reported	Adverse*	Not reported	The 7-13 mm long pter. Implants performed worse than the 15-18 mm
Balshi et al. (2013a)[90]	2 protocols: 1: Postextraction (2) Healed	3protocols: 1: 1stage-freehand 2: 1stage-CADguide 3: 2-stage-freehand()	2 protocols, pending primary stability (1) Immediate abutment. Suture. Temp. Pmma (since 2000) / CADCAM-planned (since 2004) - Teeth in a day vs (2) Healing 6-8 mths	6i+2pter+2zyg-12u-mcFDP-screw	"Osseointegration"	Not reported	Titanium oxide surface performed better than machined Branemark implants
Rodriguez et al. (2012)[91]	Not reported	Ab, La., Flap, Pter-med.10-15°/mes-dis.70°, 2-stage	Healing 4months (2-7mths)	6i+2pter-12u-mcFDP-screw /part-FDP	1: SurgSucc 2: Adverse*	Not reported	Pterygoid and conventional implant comparable outcomes
Penarrocha et al. (2012)[92]	Healed	GA+La. Drill/Osteotome. Palatal positions(35i). Autograft-articles+xenograft-bovine covered. Pterymax(10i) XtraSinus-zygomatic.(4i) / frontomax buttress (30i); nasopalatal (6i); 2-stage.	Healing 3 months	tilt-10/12u-FDP/Overdenture	Adverse* SuccSurv(Buser)	Not reported	Pterygoid & palatal and conventional implant comparable outcomes
Penarrocha et al. (2009)[93]	Healed	GA+La. Drill/Osteotome. Palatal positions. Autograft-articles+xenograft-bovine covered. XtraSinus-zygomatic. 2-stage.	Softlined denture. Healing 2+1 months	6i+2pter +/-zyg mc/ga-FDP-screw	Adverse* OPXBone SuccSurv(Albrekt86)	Satisfaction-VAS	Palatal and conventional implant comparable outcomes
Penarrocha et al. (2009)[94]	Healed	GA+La. Drill/Osteotome. Flap. 2-stage	Healing 3 months.	6i+2pter-FDP-screw/cem.	Adverse* OPXBone SuccSurv(Albrekt86)	Satisfaction-VAS	Pterygoid and conventional implant comparable outcomes
Balshi et al. (2005a)[95]	2 protocols: 1: Postextraction (2) Healed	Not reported	2 protocols, pending primary stability (1) Immediate abutment. Suture. Temp. Pmma - Teeth in a day (522i) --> ? Months 2: Healing4-	6i+2pter+2zyg-12u-mcFDP-screw	"Osseointegration"	Not reported	No difference between Mark III and Mark IV Branemark implants

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	AO2014
			6mths (318i)				
Balshi et al. (1999)[96]	Not reported	La. 2-stage.	Healing 5-6 months	6-8i+2pter-12u-mcFDP-screw	AdverseBio l OPXBone	Not reported	No difference between standard and self-tapping Branemark implants

Surgery: Ab.= antibiotics; GA / La = general / local anesthesia;
Prosthesis: mc= metal ceramic/ac=all ceramic/ga=gold-acrylic; CoCr=cobolt-chrome; u=unit;
Outcome: PAX / OPX = Periapical / Panoramic radiographs; SuccSurv= clinical success or survival

Table 22. Results of studies designed to report effects of bone augmentation with simultaneous or delayed implant placement reporting an effect of a particular implant design feature on one or more treatment outcomes

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	FINDINGS
Zinser et al. (2013-2012e)[97]	2 protocols: 1 & 2 stage. Ab. GA/La. Sinus_later_autograft-iliac/chin/ramus/symphysis +/-iliac-block-hor./vert.onlay + Membrane-collagen --> 3 mths (autograft) 5 mths (autograft+allograft) / 6 mhts (allograft+xenograft)	Ab. GA/La. As for 2-stage procedure.	3 months (autograft) 6 months (allograft +xenograft) / 3-4 months if 2-stage	Crown(124) FDP(642i) Overdenture(279i)	1: SurgCompl ic/Success 2: PA/OPGXbone SuccSurv	Not reported	Multivariate analyses indicated that implant design or surface does not influence outcome.
Dasmah et al. (2013-2011e)[98]	Ab. GA. La. Flap. 2 protocols: R: Autograft_iliac_block-onlay vs L: Iliac_particulate-onlay+PrP + Sinus-lateral- Iliac_particulate-inlay (R) + PrP (L) --> 6 months	Not reported	Healing 6 months, stability-RFA	8i-mc-FDP-screw	PAXBone SuccSurv	Not reported	Implant length does not influence outcome.
Sjöström et al. (2007)[99]	Ab. GA. 2 protocols: 1. LefFort1-fracture, Autograft_iliac-interpositional(n=5) 2. Ant.onlay+Nasalfloor-inlay (24p) (+ sinus (6p) / post.onlay(18p) --> 6 months	Ab. La. 2-stage	Healing 6-8 months	6-8i-FDP	1: SurgCompl ic/Success 2: Adverse* PAXbone Stability-RFA SuccSurv	Not reported	Multivariate analyses indicated that Implant length does not influence outcome within 10-13mm versus15-18mm
Chiapasco et al. (2007)[100]	Ab. GA. LeFort1-fracture, Autograft_iliac-block-interposition --> 4-8 months	Not reported	Healing 4-8 months	4-10i-FDP/Overdenture (19p/20p)	1: Surgerysuccess(98) 2: PAXBone Perioindice SuccSurv	Satisfaction-Likert-3p	Implant length does not influence outcome when chosen to engage the grafted bone. The effects of different implant systems were not reported
Hallman et al. (2005)[101]	GA. LeFort1-fracture, Autograft_iliac-block-interposition midline+Sinus-Iliac-particulate --> 6 months	Ab. La. 2-stage	Healing 6 months	5-8i-mcFDP-screw	1: SurgCompl ic/Success 2: PAXBone SuccSurv	Satisfaction-VAS	Implant system influence outcome. However, possible effect of learning curve since first patients received implant brand A and the following group brand B.
Becktor et al. (2004)[102]	Ab. GA. 3 Protocols (1990-94/1994-1996). 1. (1994-1996). Autograft_Iliac_block_hor-vert-onlay/sinusinlay (24p) --> 4-7 Mths	Ab. GA. 1. 2. (1990-1994). Autograft_Iliac_block_hor-vert-onlay/inlay+7-15mm-i. (40p, 260i) vs 3. Non-grafted (118p/683i). 2-stage	Healing 5-12months (av.9) graftgroup / 5-14months (av.7) nongraft-group	ga-FDP Bar-Overdenture	1: Surgerysuccess 2: PAXBone Perioindice SuccSurv	Not reported	Implant length influence outcome. 15mm implants perform better than 10mm, which perform better than 6-8mm. However, tables include implants placed both in grafted and in non-grafted cohort

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	FINDINGS
Pinholt (2003)[103]	Ab. GA+La Sinus-lateral-Autograft-Iliac(/symphysis/ramus)-corttrab-block+particulate + (Edentulous: Block secured to lateral crest -> 4.5 months	Ab. Flap 2-stage	Healing 8 months	10i-FDP / 7-8i-overdenture	1: SurgCompl ic/Success 2: Histology 3: Adverse* PA/OPGXb one	Not reported	Implant system influence outcome. However, possible effect of learning curve since first patients received implant brand A and the following group brand B. Complex and incoherent data matrix
Becktor et al. (2002)[104]	GA. 4 protocols- 1 2-stage, 2-4:1-stage. 1. Autograft_Iliac_segment-block+particulates-onlay+Sinus-lateral-inlay. Resilient denture (24p) -> 4-7 Months	GA. 3 protocols: 1: segment_block-inlay_Nasalfloor+Sinus_lateral+9imp. -- 2: Segment-block-onlay + 3x3imp. -- 3: Full-block -onlay+8imp. All: Autograft_Iliac_block+particulates, 4(1): 2x3implants. 2-stage. Resilient denture.(66p)	Healing 5-12 months	FDP(68p) Overdenture(4p)	1: SurgCompl ic/Success 2:"Failure"	Not reported	Multivariate analyses indicated that implant length influence outcome. 15/18/20mm long implants perform better than 10/13mm, which perform better than 7/8mm
Lekholm et al. (1999)[105]	5 protocols: 1/2. Autograft_onlay(general & local(n?) 3. Autograft_sinusinlay(?p) 4. Onlay+sinusinlay (?p) 5. LeFort+Autograft_(?p) --> 4-5 months (25p)	Same 5 protocols, 1. +2x3imp. (33p (21plocal) 3. +2imp. (55p) 4. +2+2x3imp.(13p) 5. 3+2x3 imp. (23p) (125p, 624i in grafted bone+157 non-grafted)	Not reported	FDP Overdenture	Adverse-Biol SurgSucc (n.r)	Not reported	Implant design influence outcome.One design showed less success than other designs from same manufacturer
Keller et al. (1999)[106]	GA. LeFort1-fracture, Autograft_iliac_block-interposition midline-+Sinus-Iliac-particulate --> 6 months (4p,21i)	GA. LeFort1-fracture, Autograft_iliac_block-interposition midline-+Sinus-Iliac-particulate, 2-stage. Resilient denture (21p, 183i)	Healing 6 months	3-6i-bar ball-overdenture	1: SurgCompl ic/Success 2: SuccSurv	Not reported	Implant length influence outcome. 18 & 20 mm implants performed better than 10/13/15 mm. However, potential influence by implant design
Keller et al. (1999)[107]	GA. 3 protocolsx 2/1-stage. 1: LeFort1-fracture, Autograft_iliac_block-nasalfloor-+Sinus-Iliac-particulate (37p), 2/3: LeFort1/crestalFlap. Autograft_Iliac_corticocanc-block+particulates-nasal floor / sinus-lat. Resilient denture --> 6 months (31p)	2&3: As for 2-stage. 2x3implants, 2stage. Resilient denture. (87p)	Healing 6 months	FDP(45p) Fix-Remove(10p) Overdenture(14p)	1: SurgCompl ic/Success 2: SuccSurv	Not reported	Implant length may influence outcome, but no data presented to support statement. Long implants preferred to stabilize graft.
Watzek et al. (1998)[108]	GA. 3 protocols: 1: Sinusgraft_lateral_Autograft_Iliac_cancellous vs 2: _iliac+allograft_HA/_xenograft_bovine --> 3-8 months (auto) / 6 motnhs (allo)	Ab.	Healing 6 months	6-8i-bar-overdenture FDP	1: SurgCompl ic/Success 2: Adverse* OPGXbone	Not reported	Implant system does not influence outcome. The two systems were comparable
Nyström et al.	GA. LeFort1-fracture, Autograft_iliac_block-	La. 6 implants. 2-stage	Healing 6 months	6i-FDP	1: SurgCompl	Not reported	Implant length may influence outcome,

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	FINDINGS
(1997)[109]	interposition midline-+Sinus-Iliac-particulate --> 6 months				ic/Success 2: SuccSurv		but no data presented to support statement. Long implants preferred to stabilize graft.
Köndell et al. (1996)[110]	Healed -6-38yrs edentulous	GA. Autograft_rib-2x5cm inlay-nasal+sinus+2x2-3implants, 2-stage	Healing 6-11 months	ga-FDP-canti Ceka-bar-Overdenture	1: SurgCompl ic/Success 2: PA/OPGXb one SuccSurv	Not reported	Implant length influence outcome when placed in ribs. 10mm implants performed better than 13mm as well as 7mm implants
Neukam (1996)[111]	Not reported	Autograft_iliac-onlay. 2-stage	Healing 2-16 months	FDP	1: SurgCompl ic/Success 2: Adverse* PAXbone	Not reported	Multivariate analyses indicated that implant length influence outcome.10+mm implants performed better than 6-7mm implants
Keller et al. (1994)[112]	Not reported	GA. LeFort1/crestalFlap. Nasalfloor/Sinus_lateral_autograft_Iliac_corticocanc-block+particulates+2x3implants, 2-stage. Resilient denture.	Healing 6 months	Not reported	1: SurgCompl ic/Success 2: SuccSurv	Not reported	Implant length may influence outcome, but no data presented to support statement. 18mm preferred to stabilize graft.

Surgery: Ab.= antibiotics; GA / La = general / local anesthesia;
Prosthesis: mc= metal ceramic/ac=all ceramic/ga=gold-acrylic; CoCr=cobolt-chrome; u=unit;
Outcome: PAX / OPX = Periapical / Panoramic radiographs; SuccSurv= clinical success or survival

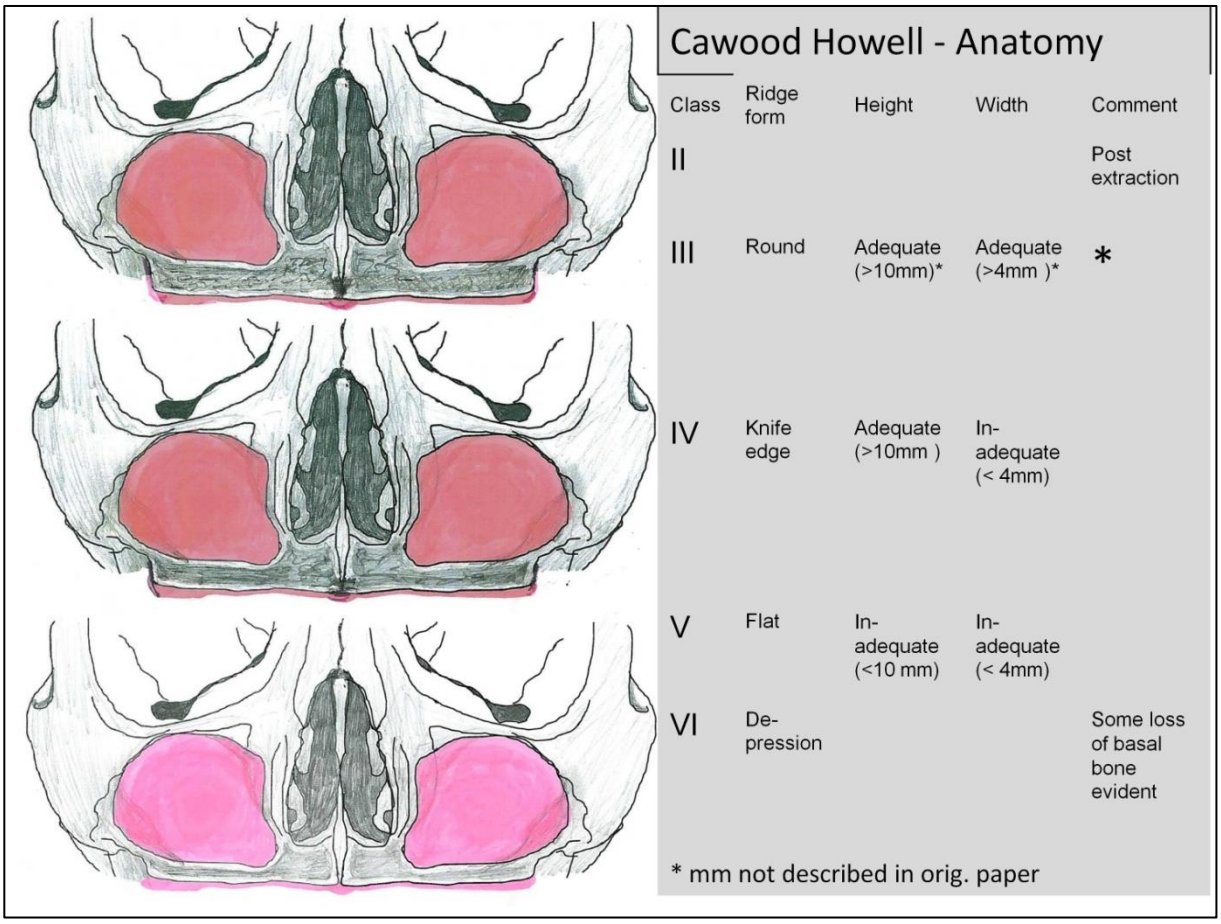
Table 23. Results of studies designed with no *a priori* stated objective to assess a particular implant design feature,

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	FINDINGS
Jemt et al. (2011)[113]	Healed minimum 3(Md) or 6-8 (Mx) months	Flap. 2-stage	Healing 5-8 mths	4-8i-10/12u-ga-FDP-screw-canti	Adverse* PAXBone SuccSurv(Albrekt86)	Not reported	Implant surface does not influence outcome. Early failure less prevalent with oxidized surface, but turned perform as good as oxidized on longer term
Friberg & Jemt (2008-2007e)[114]	Healed 4 months-40 years	All narrow crests height reduced. No grafting	Not reported	Not reported	Adverse* PAXBone SuccSurv(Albrekt86)	Not reported	Implant length influence outcome. Short implants performed worse than long in narrow jaws. However, this may be a seconday effect of crest height
Jemt & Johansson (2006)[115]	Healed 13.3 years	Flap. 2-stage	Healing 3-6 months	4-8i-10/12u-ga-FDP-screw-canti	Adverse* PAXBone SuccSurv(Albrekt86)	Not reported	Implant length influence outcome. 7mm turned implants in soft bone fail more than others
Widbom et al. (2005)[116]	Not reported	Not reported	Not reported	2-4i-bar-Overdenture	Adverse* SuccSurv	Not reported	Multivariate analyses indicated no effect of implant length on outcome
Ibanez et al. (2005)[117]	Not reported	Ab. Flap. Flapless(10p)	3 protocols: : A: Immediate abutments+Prefab pmma FDP --> Healing 2-3(Md) 6-12(Mx) months. Permanent vs B: immediate abutment metal-reinforced pmma FDP 4-24hours vs C: Impression, permanent mc-FDP <48hours	6-10i-mcFDP-screw	Adverse* PAXBone Stability-RFA SuccSurv(Albrekt86)	Not reported	Implant design or length does not influence outcome.
Degidi & Piattelli (2003)[118]	2 protocols: 1: Postextract (187i) vs 2: Healed (235i)	Flap. 2 protocols: 1-stage or 2-stage	4 protocols: 1: Healing 8-10 weeks 2/3/4: Prefab FDP. Exp.1: Occluding same day (n=422) Exp.2: Non-occluding same day (INFL) (n=224) Exp 3: Permanent crown within 3 weeks	Crown-mix 8-11i-FDP-mix Bar-overdenture	PAXBone SuccSurv(AlbZarb98)	Not reported	Implant system may influence outcome. Of 6 different implant systems used, all failures (n=8) were one particular system. The data matrix is complex and incoherent. Marg.bone loss was only reported for 91/646 implants.
Kiener et al. (2001)[119]	Healed	1-stage. Membrane()	Not reported	4-6i-ball/Dolderbar-Overdenture	Adverse* Maintenance	Not reported	Implant length influence outcome.≤10-mm failed more than 12mm
Watson et al. (1998)[120]	Healed	Ab. Widest_and_longest i. as possible" 2-stage	Healing 3(md) 6(Mx) mths	Ball/Haderbar-Overdenture	PAXBone Maintenance Perioindices Stability-ptv SuccSurv(Spiekerm)	Not reported	Implant length may influence outcome. The highest high failure rates were short and wide implants
Jemt & Lekholm (1995)[121]	Subgroup 1: Autograft	Subgroups (3): (1) Atrophic, no graft	Healing 5-14 months	4-8i-10/12u-ga-FDP-	Adverse* PAXBone SuccSurv(	Not reported	Implant length influence outcome. 7mm turned implants in soft bone fail

Lead author	presurg	surg	post_surg	Prosthes	outcome	Outcome_Patient	FINDINGS
	_iliac-block-onlay (14p, 83i) --> ?months	(33p,127i) (2)Intermediate atrophy (25p,142i) (3)FixedP(76p, 449i)		screw-canti / 4-6i-bar-overdenture	Albrekt86)		more than others and especially when there is severe height resorption
Palmqvist et al. (1994)[122]	Not reported	2 protocols: 1: "planned case" 2-4 implants 2: lost implant+changeof plan: 4-6 implants	Not reported	2-4i-ball/round-Dolderbar-overdenture	Adverse* Maintenance	Not reported	Multivariate analyses indicated that implant length influence outcome. 7mm turned implants fail more than others

Surgery: Ab.= antibiotics; GA / La = general / local anesthesia;
Prosthesis: mc= metal ceramic/ac=all ceramic/ga=gold-acrylic; CoCr=cobolt-chrome; u=unit;
Outcome: PAX / OPX = Periapical / Panoramic radiographs; SuccSurv= clinical success or survival

Figure 1. Illustration of approximate remaining maxillary bone according to the Cawood-Howell bone classification system.[13] Note that the authors did not state the dimensions in millimetres in their original paper.



Cawood Howell - Anatomy

Class	Ridge form	Height	Width	Comment
II				Post extraction
III	Round	Adequate (>10mm)*	Adequate (>4mm)*	*
IV	Knife edge	Adequate (>10mm)	In-adequate (< 4mm)	
V	Flat	In-adequate (<10 mm)	In-adequate (< 4mm)	
VI	De-pression			Some loss of basal bone evident

* mm not described in orig. paper

Figure 2. PRISMA flow-chart.[12] Reports on implant supported prosthesis, in fully edentulous maxilla.

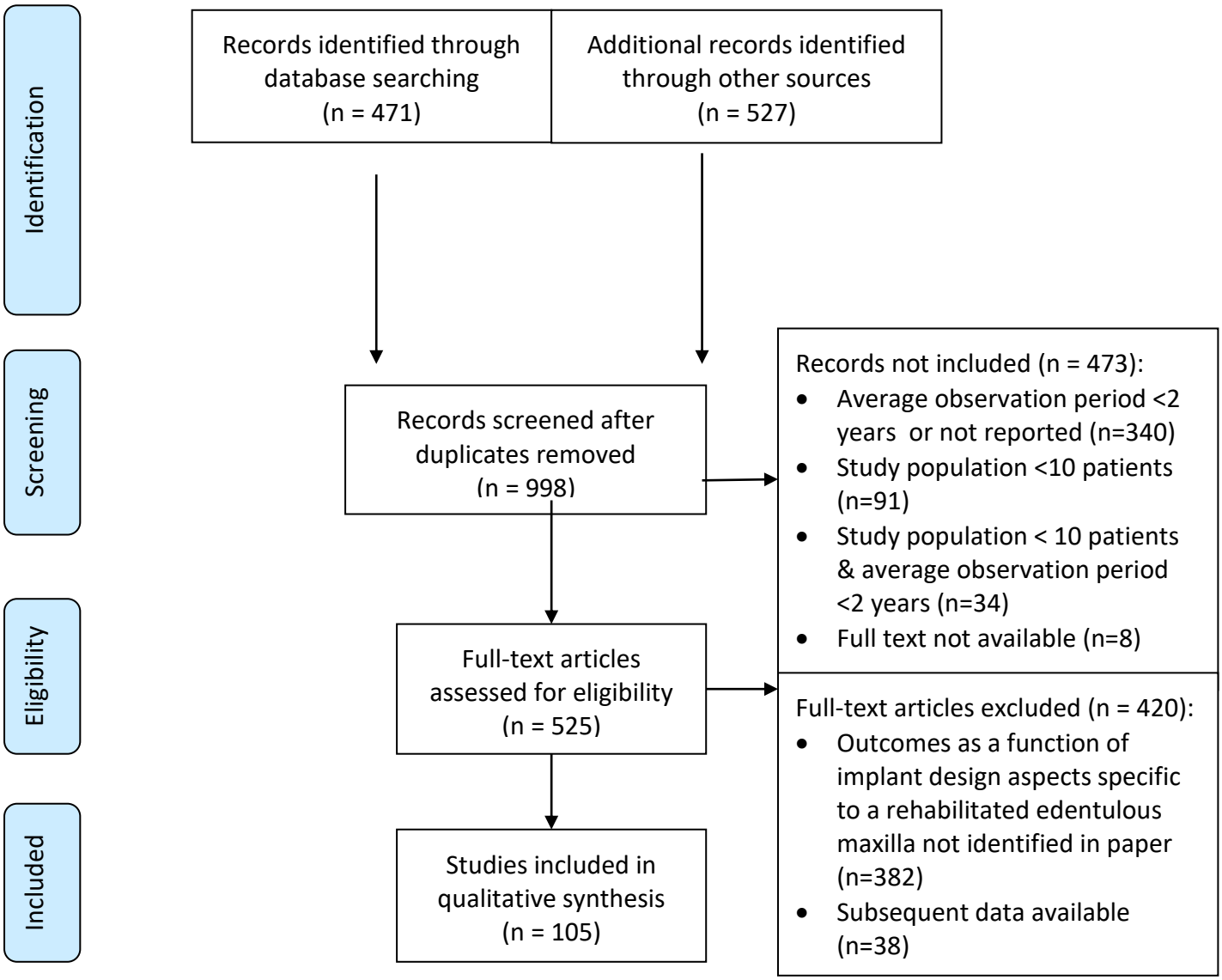


Figure 3. Examples of variations in study designs applied to appraise effects of implant design features, beyond parallel study cohort comparisons.[21] Top, placement of implants in random locations, in this case Brånemark implants with two different tap relief profiles.[34] Middle, split-mouth study, e.g., comparing effects of different CoreVent implants.[32] Bottom, comparing short Straumann implants placed in limited bone distally, with longer implants placed anteriorly in study participants with Cawood-Howell class IV maxilla.[22]

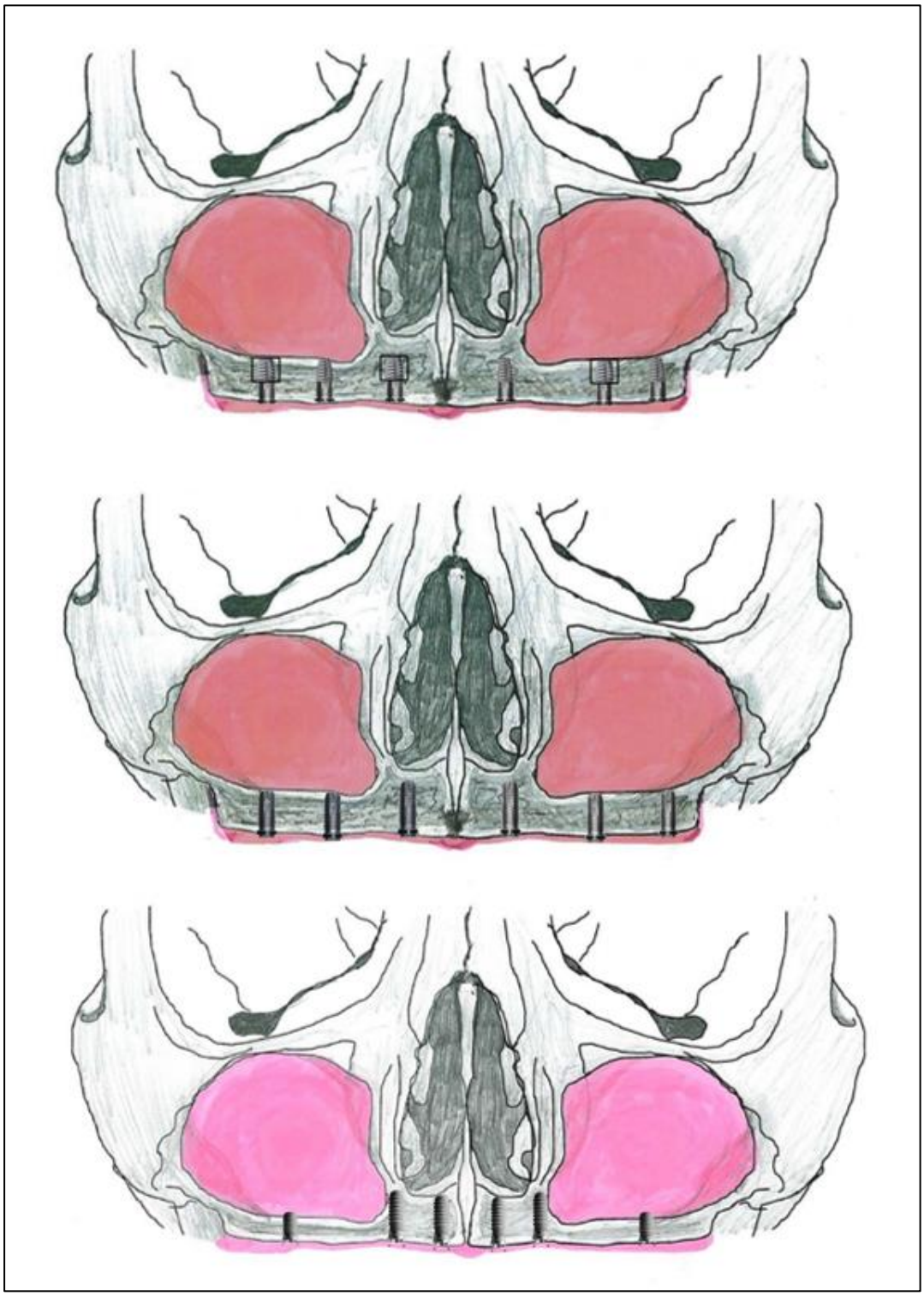


Figure 4. Examples of diversity of surgical approaches using tilted implants. Two top examples were alternatives to bone augmentation techniques in study participants with Cawood-Howell (C-H) bone class II to VI.[56, 57] Top left show four distally tilted Brånemark implants in a C-H V/VI maxilla,[57] central left two axial and two 30-45° distally tilted Brånemark implants in C-H III/IV maxilla,[55] bottom left two axial and two 30° distally tilted "externally hexed" implants in immediate extraction sockets (C-H II).[44] Note relative gain in tilted implant lengths versus axial as a function of increasing bone height. Right figures show alternatives to bone augmentation techniques in study participants with C-H V/VI bone, top two distally+four mesially 25-30° tilted + two Brånemark implants in palatal vault,[56] central two axial + four 25-30° mesially and distally tilted Brånemark implants[52] and bottom, two axial and two distally tilted implants, but through the sinus to obtain fixation in four layers of cortical bone.[39]

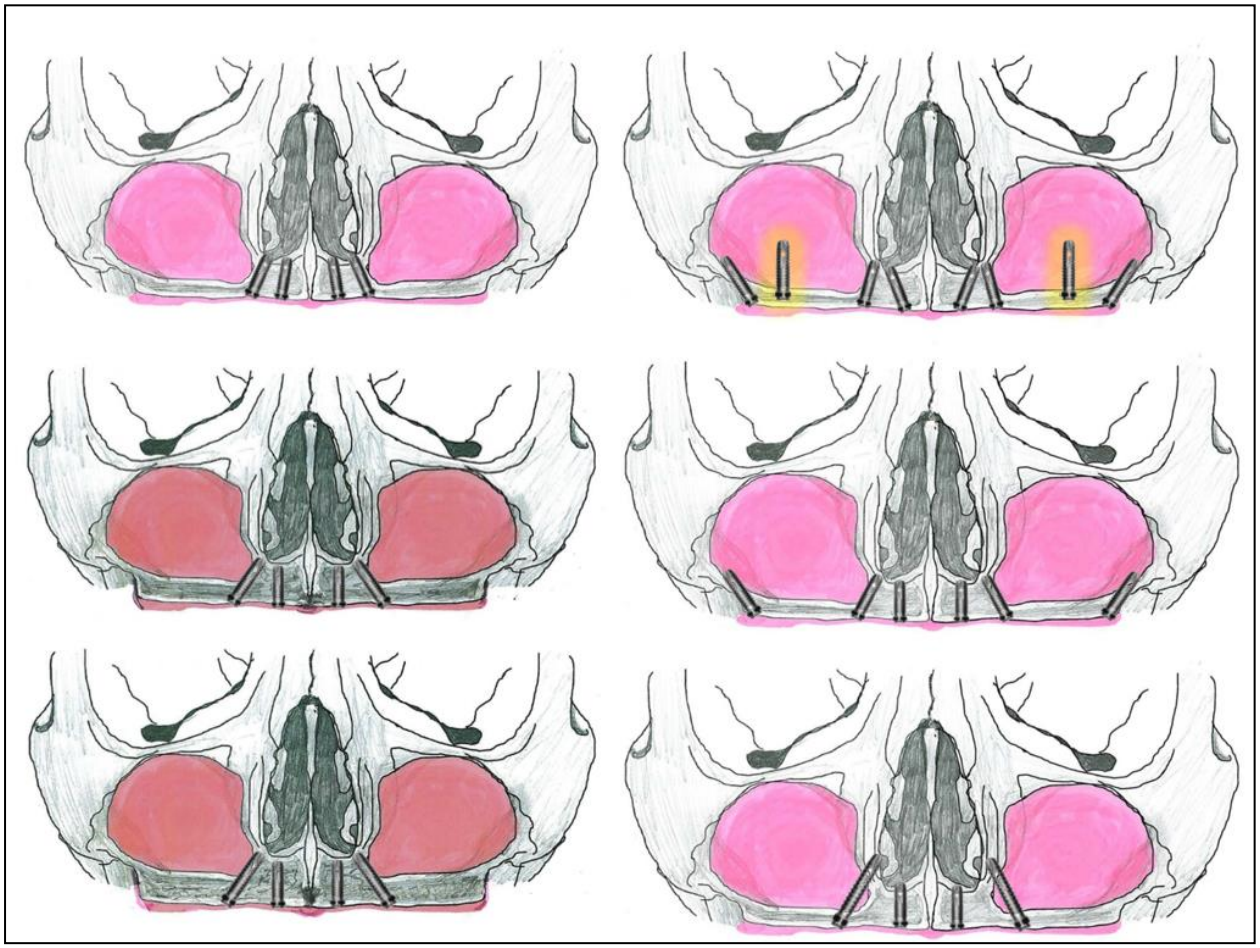


Figure 5. Examples of diversity of surgical approaches using zygomatic implants in study participants with Cawood-Howell bone class IV to VI. Top left shows two trans-sinus zygomatic plus e.g., two conventional implants,[87] bottom left four trans-sinus zygomatic,[86] top right two extra-sinus zygomatic plus, e.g., four conventional implants,[64] bottom right four extra-sinus zygomatic implants.[68]

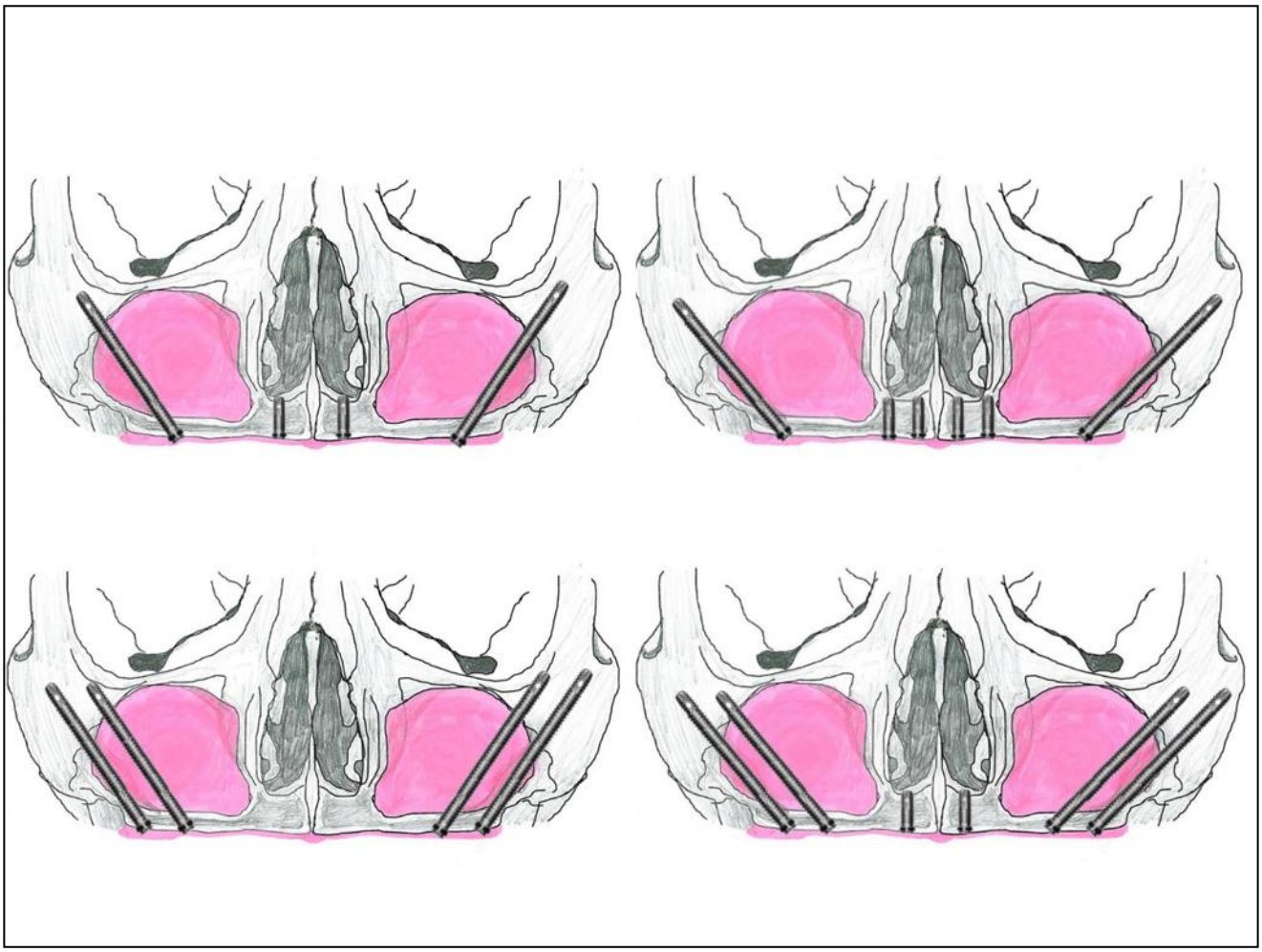


Figure 6. Examples of use of pterygomaxillary implants in study participants with Cawood-Howell bone class IV to VI. Top, two Brånemark pterygomaxillary plus six conventional Brånemark implants,[96] bottom, two Brånemark pterygomaxillary plus six Brånemark conventional implants plus two zygomatic implants, AKA “teeth-in-an-hour” concept.[95]

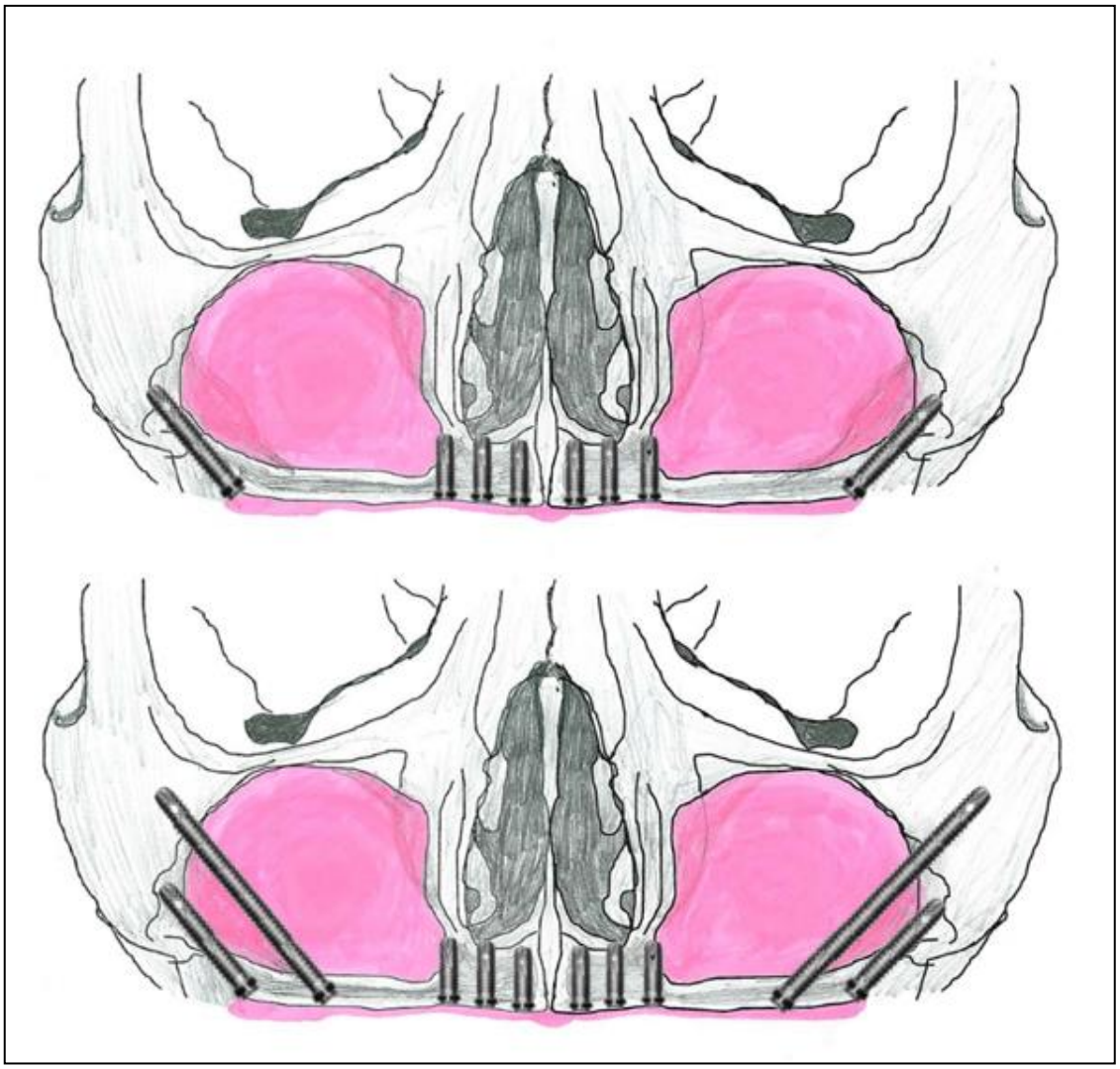


Figure 7. Examples of diversity of surgical approaches for bone augmentation with simultaneous or delayed implant placement in study participants with Cawood-Howell bone class IV to VI. Top, left, LeFort 1 Fracture with interpositional fixation and immediate or delayed placement of e.g., 6 Brånemark implants.[109] Middle, left full-arch onlay block with e.g., 6 immediate Brånemark implants.[104] Bottom, left, segmental block onlay with delayed Brånemark implants. Top, right, segmental inlay blocks in sinus with six immediate loading Brånemark implants,[112] Middle, right segmental inlay blocks in sinuses and nasally with e.g., nine immediate loading Brånemark implants,[106] Bottom, right, segmental blocks in sinus plus horizontal onlay anteriorly with Brånemark implants placed 4 to 7 months later.[102]