



Oral health-related quality of life and satisfaction in edentulous patients rehabilitated with implant-supported full dentures all-on-four concept: a systematic review

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Abstract

Objective Address oral health-related quality of life (OHRQoL) and patient satisfaction rehabilitated by the all-on-four concept as the primary outcome.

Material and methods A search was performed in the PubMed/MEDLINE, Web of Science, and Cochrane databases according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis criteria (PRISMA). The PICO question was used to address the following specific question: “What is the level of oral health-related quality of life and satisfaction in edentulous patients and with atrophic jaws who received dental implants for full-arch implant-supported restorations following the all-on-four in the mandible or maxilla?”

Results Eleven studies including 693 patients aged 55 to 71 years were selected. The shortest follow-up period was 3 months and the longest, 7 years. Regarding the OHRQoL assessment method and patient satisfaction, the oral health impact profile (OHIP) and the visual analog scale (VAS) were the most used.

Conclusion OHRQoL and satisfaction in patients whose rehabilitation was based on the all-on-four concept were high. However, the current evidence is still limited by the quality of the available studies, making long-term randomized studies necessary to establish the real effectiveness of this surgical-prosthetic approach.

Clinical relevance Carefully analyze the aspects related to satisfaction and oral health-related quality of life of rehabilitated patients with implant-supported total prostheses made according to the all-on-four concept, aiming to achieve success through procedures with greater predictability and less complexity, as these are directly associated with recovery oral health of edentulous individuals with less morbidity and minimized costs.

Keywords All-on-four · Edentulous atrophic maxilla · Tilted implants · Immediate loading · OHRQoL · Satisfaction

Introduction

The all-on-four concept is based on the use of four anterior implants to support a provisional prosthesis, fixed and with immediate loading in totally edentulous jaws. The two

most anterior implants are installed axially, while the two posterior implants are positioned at a distal angle in order to minimize the length of the cantilever and allow the use of prostheses with up to twelve teeth, thus increasing the masticatory efficiency of these prostheses [1–4].

Nevertheless, Brånemark and collaborators described approaches similar to this concept [5]; however, Maló and collaborators are referred to as the precursors when describing this technique in 2003 [3]. The original Brånemark protocol recommended that implants be installed vertically, usually resulting in a distal length of the cantilever up to 20 mm [2]. However, it was found that this could generate high levels of tension and flexion, both in the implants and in the surrounding bone, resulting in marginal bone resorption and consequent impairment of implant survival [6].

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The rehabilitation of totally edentulous jaws that have suffered atrophy is faced with a series of limitations. In atrophic edentulous jaws, a difficulty to be overcome is the proximity of the mandibular nerve. In these cases, bone grafts and other regenerative procedures may represent a solution to increase bone volume before implantation surgery [7]. However, these surgical interventions are not amenable to acceptance by all patients [8].

The edentulous maxilla with atrophy, in turn, often does not have enough volume of alveolar bone, especially in the posterior region, where severe bone resorption can occur as a result of tooth loss [9]. Another important point to be noted refers to the location of the maxillary sinus [10]. In view of these aspects, several alternative clinical procedures have been proposed for the installation of osseointegrated implants in the posterior atrophic maxilla in order to remedy these problems; one of them is the maxillary sinus lift surgery. Despite the excellent results of this procedure, several complications have been reported in relation to surgical risk, such as morbidity in the donor area, loss of the graft or implants, fistulas, sinusitis, and osteomyelitis, requiring great prudence both from the professional and the patient, besides being related to high financial cost [7, 11–13].

Considering the limitations of the technique described above, another therapeutic option in case of reduced bone availability is represented by the use of shorter implants [14, 15]. However, in the posterior maxilla, a minimum height of the alveolar bone crest of 6 to 7 mm respected for a safe installation of implants smaller than 8 mm. Likewise, in the case of atrophic posterior mandible, where superficialization of the alveolar nerve may be present, even the use of short implants may not be recommended, due to the potential risk of damaging the nerve [8].

Due to the considerations expressed above, the installation of inclined implants for the rehabilitation of edentulous patients has often been proposed, and its association with immediate loading, especially in the presence of atrophic jaw, has become widely spread among professionals [8].

In 2020, Arcas-Sanabre et al. [16] treated patients with edentulous jaws using 4 to 6 implants, or zygomatic and conventional, performing horizontal crest augmentation combining autologous bone with Bio-Oss and membranes [16]. In the mandible, the inclination of the distal implants can prevent damage to the mandibular nerve, and in the maxilla, it becomes an alternative to bone graft procedures. In this way, conventional length implants can be installed, thus increasing the primary stability in cortical bone [17]. In addition, by increasing the distance between the implants and reducing the length of the cantilever, biomechanical advantages will be more easily achieved, as there is a better distribution of loads [18–20].

Although clinical evaluation is indispensable and characteristics such as success and survival rates, failure rates,

temporal changes in proximal bone levels, technical and biological indications, and complications are essential [21, 22], the perception of the result reported by the patient is becoming, progressively, paramount in the assessment of the definitive result of dental treatment [23]. For this reason, this systematic review aimed to address quality of life related to oral health (OHRQoL) and satisfaction of patients rehabilitated by the all-on-four technique.

Oral rehabilitations usually involve more than one professional, such as surgeons in cases of bone grafting, implantodontists in the placement of implant pins, prosthetics for planning the implant prostheses to be made, and prosthetics in making the prostheses, in addition to the patient who has a large participation throughout the rehabilitation process [24]. The effect of patient satisfaction is essential to assist both the patient and the dental surgeon in selecting the most appropriate rehabilitation treatment option. The most commonly used perception for evaluating implant treatment in toothless patients is OHRQoL. Patient satisfaction can also be assessed by quantifying the patient's opinion regarding prosthetic rehabilitation [23].

After a systematic review of the literature, the authors of the present study found some studies that evaluated the effect of the fixed all-on-four prosthesis with implants on the satisfaction and OHRQoL of toothless patients [25–30]. High level of patient satisfaction, based on questionnaires in relation to function, phonetics, and esthetics, was reported in two studies with a 1-year follow-up [31, 32]. OHIP (impact profile on oral health) in patients rehabilitated with the all-on-four approach was evaluated in other studies with 2.8 years [33] and 7 years [34] of follow-up.

Therefore, the objective of this systematic review was to assess satisfaction and oral health-related quality of life of rehabilitated individuals with full implant-supported prostheses on distally inclined implants.

Material and methods

Protocol and registration

This systematic review was designed following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) and was conducted according to the models proposed in published reports. The study was registered at the International Prospective Register of Systematic Reviews (Prosero: CRD42020222141).

Eligibility criteria

The PICO question (population, intervention, comparison, outcomes) was used to address the following specific

question: “What is the level of oral health-related quality of life and satisfaction in edentulous patients and with atrophic jaws who received dental implants for full-arch implant supported restorations following the all-on-four in the mandible or maxilla?” According to these criteria, the study population was composed of patients who had total edentulous and/or atrophic jaws. The intervention was the all-on-four technique and the comparison, other dental rehabilitation techniques, with respect to the following outcome: OHRQoL and patient satisfaction.

Inclusion criteria were as follows: (I1) randomized controlled clinical trials (RCTs), (I2) prospective studies, (I3) retrospective studies, (I4) in vivo clinical studies, (I5) with at least 10 patients, (I6) with a minimum follow-up period of 3 months, and (I7) load applied within 48 h after implant surgery. The exclusion criteria were as follows: (E1) literature reviews, (E2) systematic reviews, (E3) case report, (E4) biomechanical trials, (E5) in vitro studies, (E6) animal studies, (E7) analyzes of finite elements, (E8) zygomatic implants, (E9) mini-implants, (E10) unitary implants, (E11) non-all-on-four treatment concept, and (E12) with incomplete data that did not allow the collection of information.

Information sources and search strategy

The selection of the articles was carried out by two independent reviewers previously calibrated (G.S.Y.G. and K.M.F.M.). The authors conducted an electronic search on PubMed/MEDLINE, Web of Science, and Cochrane Library for articles published until October 2020 according to the eligibility criteria, using the following search term: “All-on-four; Edentulous atrophic maxilla; Tilted implants; Immediate loading; OHRQoL; Satisfaction.” The search strategy was as follows:(((edentulous atrophic maxilla OR edentulous OR alveolar ridge atrophy OR atrophy maxilla OR atrophic maxilla OR atrophic mandible OR atrophied maxilla OR “Jaw, Edentulous”[Mesh] OR “Alveolar Bone Loss”[Mesh] OR “Mouth, Edentulous”[Mesh] OR edentulous mandible OR edentulous jaw))) AND (((fixed implant prosthesis OR immediate function OR full-arch fixed dental prostheses OR cross-arch fixed dental prosthesis OR “Dental Implant-Abutment Design”[Mesh] OR inclined abutment OR angulated abutment OR straight abutment OR All-on-4 (R) OR all-on-4 concept OR all-on-4 surgery OR all-on-4 OR all-on-four OR all on four OR all on 4 OR four dental implants OR 4 dental implants OR dental AND (tilted implants OR axial implants OR distal tilted implants OR distal angulated implants OR distal inclined implants OR distal angle implants OR axial dental implants OR axially implants))) OR ((all-on-4 AND (“Immediate Dental Implant Loading”[Mesh] OR “Dental Implants”[Mesh] OR immediate loading OR early loading)))) AND ((“Immediate Dental Implant Loading”[Mesh] OR “Dental Implants”[Mesh] OR

loading protocol OR immediate loading OR early loading)) AND ((OHRQoL OR Oral Health-related Quality of Life OR Oral Health Impact Profile OR OHIP OR Quality of life OR Satisfaction OR Success AND Survival Rate)).

In addition, a manual search was performed for articles published in the main journals in the areas involved and in the gray literature. As a result, one more relevant article was found in the journal *Quintessence International* [29].

Study selection and data collection

Initially, articles were selected by title and abstract according to the pre-established eligibility criteria, and all discrepancies about the searches carried out in the databases were analyzed by a third reviewer (W.G.A.), through a consensus meeting. One of the authors (G.S.Y.G.) collected the relevant information from the articles, and a second author (K.M.F.M) reviewed all the information collected. In this way, the two reviewers (G.S.Y.G and K.M.F.M) collected the relevant information from the articles independently. The variables collected from the articles were as follows: (1) author/year, (2) country, (3) types of studies, (4) number of patients, (5) sex, (6) average age, (7) location of the study, (8) follow-up, (9) condition of the alveolar crest, (10) characteristics analyzed, (11) jaws, (12) number of maxillary prostheses (implants), (13) number of mandibular prostheses (implants), (14) inclination of the distal implants, (15) insertion torque for immediate loading, (16) radiographs, (17) definitive prosthetic rehabilitation, and (18) results.

Risk of bias

Two investigators (G.S.Y.G and K.M.F.M) assessed the quality and risk of bias of the studies included in this systematic review using the Newcastle-Ottawa Table for non-randomized controlled studies (NRS).

Additional analysis

An inter-examiner test (Kappa test) was performed to verify the similarity of the selection of studies in the databases between the two examiners. And, for any disagreements, a consensus meeting was opened with all the authors.

Statistical analysis

There was not enough data available on RCTs, making analysis based on the effect size (meta-analysis) impossible. In addition, the data was derived from a series of small, low-variance studies. Consequently, comparisons of outcome measures were based on weighted averages using a variance component analysis, with a set of $p \leq .05$ (JMP Statistical Software, SAS Institute, Inc., Cary, NC, EUA).

Results

Description of studies and results of the search

A search of the databases retrieved 654 references, including 40 from PUBMED, 304 from the Web of Science, 310 from the Cochrane Library, and 1 from Quintessence International after a manual search of the literature. The agreement between the two reviewers in selecting the studies studied to assess the full text was excellent (Kappa coefficient = 0.79). After a preliminary reading of the titles and abstracts, 62 articles were selected, from which a total of 13 duplicate references were removed. Applying the inclusion/exclusion criteria to the titles and abstracts of the selected comparative studies, 49 studies remained. Reading their texts allowed the exclusion of 38 studies for using different techniques from all-on-four (ex: all-on-6, all-on-2, all-on-3, V-II-V), zygomatic implants or mini-implants, single implants, or for presenting insufficient data for data collection. They were also excluded for not reporting patient satisfaction or OHRQoL (off topic) or for covering the concept of non-all-on-four treatment (off topic). Details on the search strategy are presented in the flow diagram (Fig. 1).

Included studies and design

A total of 693 patients aged 55 to 71 years were included in the studies [23, 25–34]. All studies were carried out in universities [23, 25–32, 34], except one [33] which was carried out in a dental implant center; most of which were carried out in Italy [27, 28, 30, 32, 34]. All studies included patients of both sexes. Most were prospective [26, 31, 32] or retrospective [27–29]. The shortest period of follow-up evaluated was 3 months [23, 26], 7 years being the longest [34]. All studies carried out treatment in edentulous patients, and only one study [33] did not reported the mean age of the patients (Table 1).

In general, survival rate, marginal bone loss, patient satisfaction, and OHRQoL were analyzed for complete prosthetic rehabilitation of the total mandibular or maxillary arch; 422 mandibular prostheses and 304 maxillary prostheses supported by four implants based on the all-on-four concept were delivered to patients. Most studies used insertion torque greater than 30 N.cm to apply the immediate load, except one that used 25 N.cm [23] and two studies that did not report the insertion torque used for the immediate loading of the implants [29, 33]. Large part used 30° angulation for distal implants [24, 27, 29, 31, 32], and one study [33] did not report the angulation of the implants positioned distally. Regarding the OHRQoL evaluation method and patient

Fig. 1 Study design: PRISMA flowchart of searching and selection process of titles during systematic review

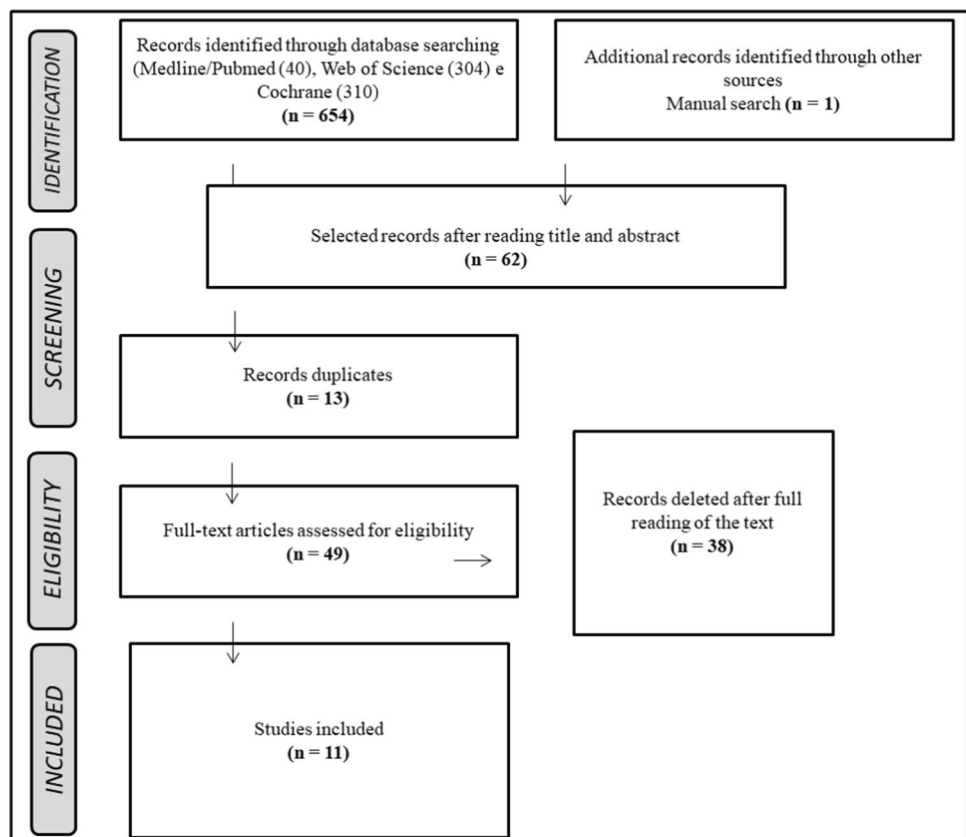


Table 1 General data on the selected studies

Author/year	Country	Design	Patients	Sex	Mean age (years)	Location study	Follow-up	Ridge condition
Francetti et al/2008 [31]	Italy	A single cohort prospective study	62	F/M	56	University	6, 12, 18, and 24 months and annually up to 5 years	Edentulous
Misumi et al/2015 [26]	Japan	Prospective	10	F/M	62	University	3 months	Edentulous
Sannino et al/2016 [27]	Italy	Retrospective	51	F/M	63.4		6, 12, and 24 months	Edentulous mandibles, with hopeless teeth, sufficient residual bone volume
Sannino et al/2017 [28]	Italy	Retrospective	85	F/M	56.5	University	3 years	Edentulous jaws
ELsyad et al/2019 [23]	Egypt	Longitudinal crossover study	16	F/M	55–65	University	3 months	Edentulous jaws
Weinstein et al/2012 [32]	Italy	Prospective	20	F/M	60.8	University	Every 6 months up to 2 years and annually up to 5 years	Fully edentulous mandible or presence of teeth with unfavorable long-term prognosis
Di et al/2013 [25]	China	Study in vivo	69	F/M	56.7	University	3 to 6 months in the first year and thereafter annually for up to 5 years	Completely edentulous arches and dentate arches with terminal dentition
Mumcu et al/ 2020 [29]	Turkey	Retrospective	33	F/M	60.5–65.6	University	6, 12, and 24 months	Edentulous maxilla
Ayna et al/2018 [34]	Japan	Study in vivo	32	F/M	71	University	7 years	Edentulous atrophic jaw
Babbush 2012 [33]	United States	Clinical study	250	F/M	NC	Dental implant center	34 months	Edentulous
Capelli et al/2007 [30]	Italy	Clinical Study	65	F/M	59.2	University	3 years	Severe jaw atrophy

F female, M male, NC no reported

satisfaction, OHIP and the visual analog scale (VAS) were the most used among the studies, evaluating function, phonetics, and esthetics. Only one study did not report the performance of complementary exams, such as radiography or tomography [26]. All studies showed high levels of patient satisfaction and OHRQoL and implant and prosthesis survival rate close to 100% (Table 2).

NRS studies were analyzed based on the Newcastle-Ottawa Scale, presenting 80 stars, being considered at high risk of bias. The methodological quality score of the studies was calculated in three components: selection of the groups (0–4 points), quality of adjustment for confusion (0–2 points), and evaluation of the exposure after the outcome (0–3 points). If one or more criteria were not met, the study would be considered “high” risk of bias. The quality of the study was assessed on a scale of 0 (high risk of bias) to 9 (low risk of bias) (Table 3).

Discussion

Rehabilitation with implants in the posterior region of the atrophic maxilla still presents a great challenge for implant dentistry, since there is a high failure rate in the treatment of atrophic maxilla with implants, due to conditions such as alveolar pneumatization of the maxillary sinus and low bone density [4]. In the same way, tooth loss and the use of a complete denture for many years can lead to severe alveolar bone atrophy in the retroforaminal zone associated with superficialization of the alveolar nerve, generally implying an increase in the patient’s pain and suffering during chewing due to the significant reduction in bone quantity available, which is an unfavorable condition for installing implants according to a conventional protocol [32].

Some authors found favorable results that allowed different prostheses to be selected and optimized for each rehabilitation based on the gain of millimeters with a horizontal bone augmentation combined with autologous bone, Bio-Oss, and membranes, optimizing the relationship between the position of the implant and the prosthetic profile; thus, mucosal coverage could be avoided and the design of the fixed prosthesis could be improved [16]. The most beneficial approach for the rehabilitation of these cases should aim to reduce the number of implants and decrease the distal cantilever, so that it does not compromise functional support and avoids demanding bone graft procedures, in addition to reducing the time and total cost of treatment [32].

A change in the practice paradigm has been to simplify clinical protocols and patient morbidity, concomitant with more satisfactory results centered on the patient according to the “current state of the art of dental practice.” The concept of all-on-four treatment is an attempt to achieve these goals, providing a predictable and relatively direct treatment option

for the rehabilitation of toothless patients with a high quality of life result [8, 21, 22, 31].

The advantages of the all-on-four concept are well known: it becomes feasible to install longer implants, the contact area between the bone and the implant and the primary stability can be increased, it is possible to reduce or eliminate the need of a prosthetic cantilever, resulting in better load distribution [25, 27], and the need for bone grafts can be eliminated; thus, there is less surgical morbidity with no clinically significant difference in success rates compared to axially installed implants [8, 21, 22] and drastically lower financial costs associated with these procedures. The concept of immediate function with screw-retained restoration based on only four implants represents a practical approach; in addition, its advantages are clinically and socially important for patients with limited dental care, treatment options, and insurance coverage [25, 27].

Immediate loading procedures for edentulous jaws have become widely popular among dentists and also among patients [8, 27] and have improved patient acceptance of implant treatment. In particular, months of complete edentulous or the use of an uncomfortable removable prosthesis can be avoided [25].

Despite all the research that has focused on the biological and biomechanical characteristics of osseointegrated dental implants, few studies address patients’ perceptions of treatment results. Assessments of treatment success often neglect the patient’s subjective feelings about comfort, function, speech, image and social inhibitions, psychological discomfort, and/or disabilities [33]. Therefore, this systematic review sheds light on patient satisfaction with OHRQoL related to the concept of all-on-four treatment, in order to clarify and consolidate the application of this protocol in different clinical situations and thus improve understanding and decision-making in daily clinical practice.

The authors of the present study agreed that a minimum follow-up period of 3 months is valid based on the premise that although primary stability is adequate soon after implant placement, it begins to decay over time and is replaced by secondary stability. Both stabilities intersect in the fourth week, but they are low; that is, it is still not suitable to expose this implant to occlusal loads, because there is a risk that the implant will fail. Therefore, one should carry out immediate loading or wait about 7–8 weeks for early loading; therefore, from the end of the first month, it is understood that reliable results can be found; and therefore, it would not be incorrect to give a follow-up evaluation of the implant that will begin during this period, but future studies should be carried out with long-term observations of these cases, in order to avoid biases that could compromise the results [35].

To assess treatment results and the impact on quality of life, one of the most commonly used tools to obtain

Table 2 Characteristics of included studies—continued

Author/year	Analyzed characteristics	Jaws	No. maxillary prostheses (implants)	No. mandibular prostheses (implants)	Distal implants inclination (°)	Insertion torque for immediate loading (Ncm)	Radiography	Definitive prosthetic rehabilitation	Outcomes
Francetti et al/2008 [31]	Plaque level, bleeding score, patient satisfaction, marginal bone loss and success rate	Mandible	---	62 (248)	30	≥ 30	PAR (PT + IH)	Full-arch fixed bridge	Implants CSR 100; prosthesis SR 100; high level of satisfaction
Misumi et al/2015 [26]	OHRQoL	Maxilla and mandible	12 (65)	4 (65)	≤ 45	≥ 30	NC	Definitive prostheses with titanium framework and reinforced resin facing	A definitive prosthesis with a metallic structure is the most effective in restoring OHRQoL
Sannino et al/2016 [27]	Survival rate, marginal bone loss, and patient satisfaction	Maxilla and mandible	28 (248)	34 (248)	30	35 - 45	PAR (PT)	Full-arch fixed bridge	Implants CSR 100; high level of satisfaction
Sannino et al/2017 [28]	Survival and success rates of implants and prostheses, changes in marginal bone level, satisfaction of patient, and clinical time required	Mandible	---	85 (340)	≤ 40	≥ 35	OPT/ PAR	Milled high-precision titanium and zirconia prostheses	Implants SR 98,21% (control) and 98,83% (test); statistical differences significant ($P = .0068$) in marginal bone loss were found between the control and test groups; prosthesis SR 100; high level of satisfaction; average required clinical time: 50 minutes (control) and 30 min (test)
ELsyad et al/2019 [23]	OHRQoL	Mandible	---	16 (64)	30	25	CBCT	Fixed prosthesis (FP) or milled bar overdenture (MB)	High level of satisfaction

Table 2 (continued)

Author/year	Analyzed characteristics	Jaws	No. maxillary prostheses (implants)	No. mandibular prostheses (implants)	Distal implants inclination (°)	Insertion torque for immediate loading (Ncm)	Radiography	Definitive prosthetic rehabilitation	Outcomes
Weinstein et al/2012 [32]	Implant survival rate, marginal bone loss, and patient satisfaction	Mandible	---	20 (80)	30	≥ 50	OPT/PAR	Full-arch fixed bridge	Implants: CSR 100/24, CSR 100/36, CSR 100/48; prosthesis: CSR 100; high level of satisfaction
Di et al/2013 [25]	Implant survival rate, marginal bone loss, abutment selection, complications, and patient satisfaction	Maxilla and mandible	38 (344)	48 (344)	30 - 45	35	OPT/CBCT	Full-arch fixed bridge	Implants SR 96,2%; bone loss: $0,7 \pm 0,2$ mm e $0,8 \pm 0,4$ mm; high level of satisfaction
Mumcu et al/2020 [29]	Satisfaction, quality of life, and marginal bone loss	Maxilla	33 (132)	---	30	NC	OPT	A four-implant-retained maxillary overdenture or a maxillary fixed prosthesis with all-on-four concept	High level of satisfaction and quality of life
Ayna et al/2018 [34]	Prosthetic complications, bone resorption, plaque buildup, bleeding on probing, periodontal probing depth, and OHIP	Jaw	---	32 (128)	30 - 45	≥ 35	PT	Fixed complete-arch prostheses fabricated with metal-ceramic implant-supported fixed prosthesis with a titanium framework and all-ceramic crowns and bar-retained implant-supported removable prosthesis with acrylic resin prosthetic teeth	Prosthesis SR 100; bone loss < 1,2mm; there was a dramatic subjective improvement, as assessed by the OHIP in both groups; patients must be highly motivated to maintain their personal oral hygiene

Table 2 (continued)

Author/year	Analyzed characteristics	Jaws	No. maxillary prostheses (implants)	No. mandibular prostheses (implants)	Distal implants inclination (°)	Insertion torque for immediate loading (Ncm)	Radiography	Definitive prosthetic rehabilitation	Outcomes
Babbush 2012 [33]	OHIP	Maxilla and mandible	152 (1000)	97 (1000)	NC	NC	CBCT, OPT, PAR	Full-arch fixed bridge	Implants CSR 92.2–100; high level of satisfaction; treated patients would generally be willing to recommend this treatment to others
Capelli et al/2007 [30]	Survival rate, marginal bone loss, and patient satisfaction	Maxilla and mandible	41(246)	24 (96)	25–35	30	OPT	Full-arch fixed bridge	Implants CSR 97.59; prosthesis SR 100; high level of satisfaction

NC no reported, CSR cumulative survival rate, IH individual holder, OPT orthopantomogram, PAR periapical radiographs, PT paralleling technique, SR survival rate, CBCT cone beam computed tomography

Table 3 Methodological quality assessment of NRS Newcastle-Ottawa

Studies	Selection		Comparability			Outcome		Total	Risk of bias		
	Exposed cohort	Non exposed cohort	Ascertainment of exposure	Outcome of interest not present at start	Main factor	Additional factor	Assessment of outcome			Follow-up long enough	Adequacy of follow-up
Francetti et al/2008 [31]	☆	0	☆	☆	☆	☆	☆	☆	0	7	High
Misumi et al/2015 [26]	☆	☆	☆	☆	☆	0	0	0	0	5	High
Sannino et al/2016 [27]	☆	☆	☆	☆	☆	☆	☆	☆	☆	9	Low
Sannino et al/2017 [28]	☆	☆	☆	☆	☆	☆	☆	☆	☆	9	Low
ELsyad et al/2019 [23]	☆	☆	☆	☆	☆	0	0	0	0	5	High
Weinstein et al/2012 [32]	☆	☆	☆	☆	☆	☆	☆	☆	☆	9	Low
Di et al/2013 [25]	☆	0	☆	☆	☆	☆	0	☆	0	6	High
Mumcu et al/ 2020 [29]	☆	☆	☆	☆	☆	☆	0	☆	☆	8	Low
Ayna et al/2018 [34]	☆	0	☆	☆	☆	☆	☆	☆	☆	8	Low
Babbush 2012 [33]	☆	☆	☆	☆	☆	0	0	☆	☆	7	High
Capelli et al/ 2007 [30]	☆	☆	☆	☆	0	☆	☆	0	☆	7	High

patient-based health status assessments is OHIP. The OHIP questionnaire includes two questions for each of the seven dimensions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap; the higher the score, the more satisfied the subject, except for the pain domain that works in the opposite way. Patients rate each of the 14 items (from 0 = “never” to 4 = “very often”) on a 5-point scale. Possible OHIP-14 scores ranged from 0 to 56, with lower scores showing higher OHRQoL. VAS is an auxiliary method that includes questions about general comfort, retention, chewing, language, maintenance of hygiene, esthetics, and pain/discomfort [29].

In the OHIP domains, the authors of one of the studies [23] recorded significantly higher scores compared to fixed prostheses or overdentures. This result is in agreement with other findings [36], which reported fewer OHRQoL problems compared to conventional prostheses; this fact is justified because fixed dentures or overdentures with reamed bar used with the all-on-four concept improve esthetics, speech, and self-esteem [25, 28, 32, 37], consequently increasing quality of life of edentulous patients [38–41]. Patient satisfaction with the all-on-four treatment concept was very high (rated as excellent by most patients) [25]. The improvement in OHRQoL can be attributed to implant rehabilitation according to the all-on-four concept, which minimizes soft tissue coverage [26].

The overall survival rate of implants and prostheses following the concept of all-on-four treatment was close to 100% in the studies analyzed, being in agreement with the result reported by Malo et al. [42]. The present study revealed that tilted implants did not negatively affect the success rate or marginal bone resorption [25].

Study limitations

The range of potential sources of bias in the available studies limits the meaningful interpretation of the results. The lack of data from the results of randomized clinical trials makes it difficult to evaluate this treatment approach. Therefore, the present review has some limitations that deserve to be discussed. First, different designs of implant-supported prostheses that differ from one another were considered together, neglecting any possible different performance. It must also be considered that the minimum angulation necessary to define an implant as tilted has not yet been established; in the included studies, the inclination of distal fixations in full-arch rehabilitation using this concept varied between 25 ° to 45 ° for the maxilla and mandible in relation to the occlusal plane. In some studies, the angulation was standardized, while in most cases of extreme atrophy, it was chosen individually according to the available bone. The most consistent limitation, however, is represented by the low level

of evidence for publications on this technique to date. This review, in fact, was based, for the most part, on retrospective and prospective studies, which provided indications on the prognosis of the technique.

Future research

Based on the results of this study, in order to overcome these limitations, the need for further research as randomized clinical trials with a large long-term follow-up sample is suggested to determine the effectiveness of all-on-four concept as an alternative to grafting techniques or the use of short implants or even to the conventional technique with axial implants for oral rehabilitation in patients with atrophic jaw and maxilla.

In conclusion, edentulous/or atrophic jaw patients who received dental implants for full-arch implant-supported restorations following the all-on-four concept in the mandible or maxilla showed, based on these studies, significantly high levels of OHRQoL and satisfaction.

It is important to consider that the current evidence is limited by the quality of the available studies, making more long-term randomized studies necessary to establish the real effectiveness of this prosthetic-surgical approach.

Author contribution All authors contributed to the study conception and design. GSYG and WGA conceived the ideas; GSYG and KMFM collected the data and analyzed the data; GSYG led the writing; WGA, EPR, and PHS corrected and revised the manuscript. All authors read and approved the final manuscript.

Declarations

Ethics approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

Conflict of interest The authors declare no competing interests.

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