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Survival rates of osseointegrated implants in different population groups: A systematic review

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Abstract
The aim of this study was to analyze studies that have evaluated survival rates of osseointegrated implants and identify if there was any difference between the results observed in studies conduct in Europa and Brazil. A Systematic review was performed using two search strategies on MEDLINE/PUBMED, Embase and Scopus databases to identify eligible studies published up to February 2020. Twenty-three studies that met the inclusion criteria were selected for data extraction, which revealed implant survival rates ranging from 83.3% to 100% in studies conducted in Brazil (except for one study that presented a survival rate of 56.6% due to application of immediate loading in implants presenting low primary stability), and a rage of 83.2% to 100% in the European studies. Regarding adverse events, bone loss was the most reported one in the Brazilian studies, whereas bone loss and prothesis fracture are the most present in the studies conducted in Europe. Few differences were found between the two groups of studies with respect to follow-up period and patient´s mean age. Therefore, our study suggests that outcomes of studies on osseointegrated dental implants conducted in Brazil can be extended to the European population, and vice-versa.

Keywords: survival rate, osseointegrated implants, Brazil, Europe

Introduction

As seen in many other developed or developing parts of the world, the European Union population is ageing due to increased life expectancy (over 10 years between 1960's and 2020) and has dropped fertility rates [1]. Regarding oral health, over 50% of the European population suffer from periodontitis, and among the 60-65 years-old population, its prevalence increases to 70% to 85% [2]. Brazilian population is as well aging at fast pace and is estimated to have 64 million seniors living in the country by 2050 [3]. Epidemiological studies show that between 1986 and 2003, and between 2003 and 2010, a significant improvement in dental conditions of adults took place, with notable decrease in dental loss in almost all regions [4]. However, projections show that edentulism prevalence will increase among the elderly (64-75 years old) until 2040[5]. Titanium has become the material of choice for dental implants since the 1960´s due to its biocompatibility, resistance to corrosion and mechanical properties [6].

Over the years, implant dentistry has evolved to highly predicted treatments for oral rehabilitation with implant-supported prosthesis, presenting good long-term results and high survival rates in different populations [7, 8].

Therefore, the aim of this systematic review was to identify if there is any difference regarding implant survival rates between studies involving Brazilian and European populations.

Materials and methods

Search strategy and studies selection

Two electronic searches were performed in the Medline/PUBMED, Embase and Scopus databases for studies published until February 2020. One for studies conducted in Brazil and another for studies from Europe. The search strategies included the following key word combination: "brazil" AND "dental implant" AND "implant survival" OR "survival rate" and "Europe" OR "European" AND "dental implant" AND "implant survival" OR "survival rate".

The inclusion and exclusion criteria used to conduct the studies selection are described in table 1. Initial screening of titles and abstracts was performed by two independent reviewers (C.P.V. and W.C.). After that, full-reading and selection of studies were carried out for data extraction. Figure 1 summarizes study selection process.

Table 1: Inclusion and exclusion criteria for study selection

Inclusion criteria	Exclusion criteria
Studies with adult humans	*In vitro* assays
Studies with conventional titanium dental implants	Studies with zygomatic, narrow diameter or short implants.
Studies that evaluated survival rates	Implants of different material/unconventional design
Prospective cohort, retrospective cohort study or, randomized controlled trial studies	Case reports, systematic reviews and metanalyses
English, Portuguese and Spanish publications	Articles with languages other than English, Portuguese and Spanish
Studies conducted in Brazil or Europe	Studies conducted in other regions
Studies with at least one group within the criteria	Samples including patients with risk factors for implant loss
	Studies with grafting procedures
	Deficient methodology

Table 2: Outcomes of studies conducted in Brazil

Authors	Study design	Number and type of implants	Number of patients	Patients´mean age	Loading protocol	Implant survival	Follow up period	Reported complications	Inclusion criteria	Exclusion criteria
Queiroz *et al*., 2005(11)	Non-randomized, mono-center prospective study	42 (Master Porous)	23	53.21 years	Not loaded	100%	90 days	-	Patients with compromised general health conditions that would primarily affect the ability of the patient's tissues to heal; including chemotherapy for the treatment of cancer; antimetabolic therapy (e.g., methotrexate) for the treatment of arthritis; and uncontrolled diabetes; severely impaired cardiovascular function; immunodeficiency, and kidney or liver disease; pregnant women; smokers; patients who showed signs of bruxism.	-
Ottoni *et al*., 2005(12)	Prospective cohort study	46 (Frialit-2)	23	35.4 years	Immediate and conventional loading	Conventional loading group =95.7% Immediate loading group= 56.5%	24 months	Bone loss	Good health and had to be missing 2 teeth from the anterior maxilla or mandible, between the left and right second premolars	Smokers, diabetics, patients with degenerative diseases; those who presented with oral pathology or had missing molars; those who were not properly orally rehabilitated; psychologically unstable individuals; bruxers; patients medicated with substances that might affect surgical site healing;
Melo *et al*., 2009(13)	Prospective cohort study	44 (GT; Neodent)	11	66 years	Immediate loading	100%	1 year	-	-	Systemic diseases, such as uncontrolled diabetes, that could interfere in the treatment results, alcohol and drug abuse, current treatment with steroids or history of radiation therapy in head and

										neck region
Tortamano *et al*., 2009(14)	Prospective cohort study	12 (Straumann)	12	38 years	Immediate loading	100%	18 months	No complications	One maxillary central incisor deemed hopeless for a reason other than periodontitis; absence of medical conditions contraindicating surgical intervention; sufficient alveolar bone architecture to allow primary implant stability; mucosal margin distant 4 mm to buccal/palatal bone crest and 5 mm to interproximal bone crest; attendance at all follow-up appointments.	Acute infection in the condemned tooth; periodontitis; active periodontal disease in any region of the mouth; Interproximal bone loss in the area to receive an implant; active smoking status, Fenestrations and dehiscence of the alveolar wall after tooth extraction; inadequate primary stability of the implant.
Lee *et al*., 2012(15)	Randomized controlled clinical trial	75 (Titamax; Neodent)	15	66.5 years	Immediate loading	100%	8 months	No complications	Good overall health and adequate thickness in the anterior region of the mandible for implant placement. Interforaminal distance that would allow the placement of 5 implants to support a distal extension of the cantilever beyond the mental foramina with a minimum of 14 mm and a maximum of 18 mm in length.	Non-compensated diabetic patients, patients with immunodeficiencies, patients who had used bisphosphonate drugs or received any radiation treatment in the past 5 years, and smokers.
de Carvalho *et al*., 2013(16)	Prospective cohort study	430 (150 Nobel Biocare and 280 various manufacturers - Nobel Biocare, Lifecore, Biomet 3i, Globtek)	305	49.7 years	Immediate and conventional loading	93.03%	Up to 15 years	Infection, edema and pain.	Patients in good health who required immediate implant placement.	Smokers and those with chronic illnesses; any patients with risk factors.
Landázuri-Del Barrio *et al*., 2013(17)	Prospective cohort study	64 (Nobel)		59 years	Immediate loading	90%	1 year	Suppuration, fistula, screw loosening and prosthesis fracture	Edentulous in the maxilla and mandible; wearing a full prosthesis for at least 1 year; no parafunctional habits.	Smoking, drug or alcohol abuse, and intake of bisphosphonate medication; History of head and neck irradiation; Insufficient bone height (at least 13 mm) and bone width (at least 5.5 mm) in the interforaminal region; Limited mouth opening to allow guided implant surgery.
Thomé *et al*., 2015(18)	Randomized controlled clinical trial	145 (Titamax, Neodent)	29	61 years	Immediate loading	100%	8 months	No complications	Patients with good overall health; adequate thickness in the anterior region of the mandible for implant placement; and an interforaminal distance to allow the placement of five implants	Noncompensated diabetic patients; patients with immunodeficiencies; patients who had used bisphosphonate drugs; received any radiation treatment in the last 5 years; smokers.

									to support a distal extension of the cantilever beyond the mental foramina with a minimum of 14 mm and a maximum of 18 mm in length	
Guidetti *et al*.,2015(19)	Prospective cohort study	12 (Pross)	11	43 years	Immediate loading (infra-occlusion)	83.3%	1 year	-	Having at least one tooth posterior to the edentulous area to be implanted; sufficient bone width for the insertion of a 3.75-mm implant; sufficient bone height to insert an implant of at least 11 mm; no bruxism; no systemic health issue that could compromise the technique; no drug addiction; satisfactory oral hygiene.	-
de Molon *et al*., 2017(20)	Non-randomized controlled clinical trial	20 (MasterPorous)	10	52.9 years	Conventional loading	100%	6 months	Bone loss	Implant sites free from infection; patients who presented dental implants in the posterior mandibular regions and who needed prosthetic rehabilitation	Graft placement at the surgical site and compromised general health conditions or any condition known to modify bone metabolism that would primarily affect healing process, including chemo- therapy and uncontrolled diabetes; Smokers; patients with bruxism.
Novellino *et al*., 2017(21)	Randomized controlled clinical trial	64 (Drive; Neodent)	21	49 years	Conventional loading	100%	1 year	Bone loss	Patients with no systemic contraindications (ASA I) to implant placement, and with one or more edentulous areas in the posterior maxilla (premolar and molar), a subantral bone height of 8mm, a 6.3 mm width of the residual ridge, bone density of D3 or D4 (as classified by Lekholm and Zarb) and at least a 3-month post-extraction healing period	Previous bone grafting and/or sinus lift, uncontrolled diabetes, untreated periodontitis, severe bruxing or clenching habits, pregnancy/breastfeeding; recent bisphosphonates use, alcohol or drug addiction; history of local radiation therapy.
Able *et al*., 2018(22)	Retrospective cross-sectional study	1429 Neodent implants (internal hexagon: n=128; 1-piece implants: n=138; external hexagon: n=177; Morse taper: n=986)	290	59.9 years	Not reported	99.6%	4.4 years	Gingival bleeding, bacterial plaque, prostheses fracture, prosthetic screw loosening, abutment coping loosening	Adult participants with an edentulous mandible that had been rehabilitated with immediately loaded implant-supported mandibular fixed complete-arch dental prostheses that had been in function for at least 1 year. The maxillary arch could be dentate or rehabilitated with a removable (complete or partial) or fixed dental prosthesis.	Mandibular prostheses with a conventional loading protocol or submitted to fabrication techniques that differed from that of the studied prostheses.

Silva *et al*., 2020(23)	Prospective parallel-group study	60 (Ankylos C/X, Dentsply)	20	45.5 years	Conventional loading	100%	3 years	No complications	Individuals aged ≥18 years; individuals who required a cemented-retained single-unit implant-supported restoration in the anterior/posterior maxilla or posterior mandible; individuals presenting contra-lateral and opposing teeth.	Patients with history of systemic conditions contraindicating oral surgery; long-term nonsteroidal anti-inflammatory therapy; oral bisphosphonate or antibiotic therapies; pregnancy or lactation; unwillingness to return for the follow-up visits; sites with an acute infection/inflammation

Table 3: Outcomes of studies conducted in European countries

Authors	Study design	Number and type of implants	Number of patients	Patients´ mean age	Loading protocol	Implant survival	Follow up period	Reported complications	Inclusion criteria	Exclusion criteria	Country
Haas *et al*., 1997(24)	Retrospective cohort study	1,920 (IMZ implants)	714	51.5 years	Delayed loading	83.2%	100 months	-	-	-	Austria
Kemppaine *et al*., 1997(25)	Randomized controlled clinical trial	102 (56 ITI and 46 Astra)	82	22.5 years	Delayed loading	100% ITI and 97.8% Astra	1 year	No complications	-	Uncontrolled diabetes; radiation therapy in the orofacial region; drug and alcohol abuse; and psychologic problems	Finland
Kroeplin *et al*., 2011(26)	Retrospective cohort study	97 implants	51	-	Not described	98.8%	2.5 years	-	-	-	Alemanha
Vandeweghe *et al*., 2011(27)	Retrospective cohort study	608 (Southern Implants)	329	54 years	Immediate and conventional loading	98.8%	2 years	Bone loss	Patients treated with the same implant system	-	Belgium
Arnhart *et al*., 2012(28)	Randomized controlled clinical trial	325 (NobelActive; internal abutment connection; Nobel-Active; external connection;Nobel-Replace Tapered Groovy)	177	48.7 years	Immediate loading	96.2%	5 years	Hypoesthesia, suprasctructure, mobility, implant fracture during insertion, pain, swelling, peri-implantitis, soft-tissue recession, buccal exostosis, sinus perforation	At least 18 years old; at least one permanent missing tooth in either the maxilla or the mandible; the need for fixed, implant-supported rehabili-tation; bony sites healed for at least 6 months; feasibility for immediate provisional restoration (within 24 hours) in cases of sufficient primary stability (as judged by the treating dentist); adequate bone quantity to place an implant with a diameter of at least 3.5 mm and a length of at least 10 mm, according to the safety margins commonly adhered to in implant surgery.	History of alcohol or drug abuse; general medical status that precludes surgical interventions in the jaw; head or neck cancer disease with or without irradiation in treatment history; chronic bone disease; bruxism or temporomandibular disorders; psychiatric spectrum disorders; uncontrolled diabetes; need for bone augmentation procedures; immediate implant placement in post-extractive sites; inability to adhere to the planned follow-up appointments; incapacity to give informed consent.	Austria, Belgium, Germany, Israel, Italy Spain and Switzerland
Vervaeke *et al*., 2012(29)	Retrospective cohort study	849 implants	235	56 years	Conventional loading	99.1%	31 months	Bone loss	Follow-up time of at least 2 years.	-	Belgium

Vigolo *et al*., 2012(30)	Randomized controlled clinical trial	36 (3i/implant innovations)	18	33 years	Conventional loading	83.3%	10 years	No complications	No systemic contraindication for oral surgical therapy; single-tooth bilateral edentulous sites in the canine/premolar/molar region; adequate bone width precluding the need for bone augmentation procedures; similar bone height at the implant sites allowing for the placement of implants of identical height and diameter; occlusal scheme allowing for the establishment of identical occlusal cusp-fossa contact.	-	Italy
Pozzi *et al*., 2013(31)	Randomized controlled trial	234 (28 Brånemark System Mk III and 206 NobelSpeedy Groovy, Nobel Biocare)	38	68.5 years	Conventional loading	100%	3 years	Prosthesis fracture	Full-mouth bleeding on probing and a full-mouth plaque index both lower than or equal to 25%; a residual alveolar bone crest adequate for the placement of implants at least 10 mm long and 4 mm wide; presence of teeth or dentures in the opposite jaw with a stable occlusal relationship	General medical and/or psychiatric contraindications; pregnancy or nursing; severe bruxism or other destructive habits; radiation therapy to the head or neck region in the previous 5 years; untreated periodontitis; poor oral hygiene and motivation; inability to attend regular follow-up visits; an Implant Stability Quotient of <65 at the time of the definitive impression.	Italy
Vandeweghe *et al*., 2014(32)	Prospective cohort study	36 (NanoTite Certain Tapered, BIO- MET 3i)	27	49 years	Conventional loading	94.6%	1 year	-	Lacking a single tooth; having adequate bone volume to install implants of at least 8.5 mm length and 3.25–5 mm width; no need for additional bone grafting; no unrealistic aesthetical demands which would preclude soft tissue grafting.	-	Belgium
Passia et a., 2019(33)	Prospective pilot-study	7 (Root Line, Promote, Camlog Biotechnologies)	11	66.7 years	Conventional loading	100%	10 years	Prosthesis fracture	-	-	Germany

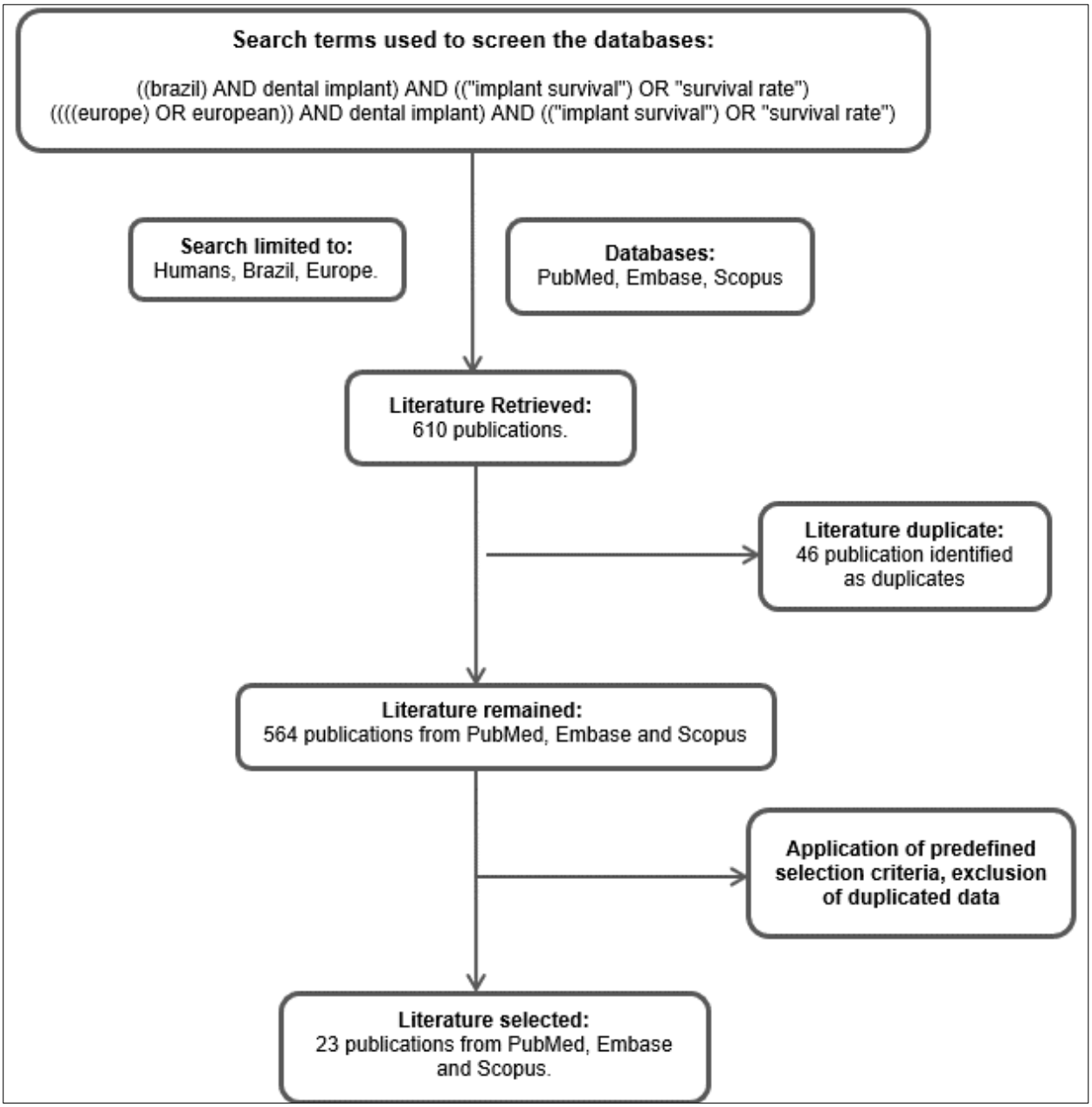

Fig 1: Flowchart of study selection.

Quality assessment of included studies

The risk of bias for RCT was assessed using Cochrane Risk of Bias tool (RoB 2.0) [9] and the Risk of Bias in Non-randomized Studies (ROBINS-I) [10] for observational studies

Results

The search for studies that have reported survival rates of osseointegrated implants in Brazilian and European populations resulted in 610 publications, with 23 of them remaining for data extraction. Thirteen of the selected studies were conducted in Brazil and 10 in European countries. These include retrospective cohort, retrospective cross-sectional, prospective observational cohort, prospective observational parallel group, and randomized studies. In the Brazilian studies, a total of 770 patients were followed, with mean ages ranging from 35.4 to 66.5 years, which resulted in 2443 implants evaluated.

Implant survival rates ranged from 56.5% and 100%, in a follow-up period of 90 days to 15 years. European selected studies evaluated a total of 4214 implants in 1682 patients who presented mean ages between 22.5 and 68.5 years. Implant survival rates ranged from 83.2% to 100%, in a follow-up period of 1 to 10 years. The selected studies assessed implants submitted to conventional or immediate loading, and sometimes both. Regarding adverse events, bone loss was the most reported in the Brazilian studies, whereas in the European studies, bone loss and prosthesis fracture are the most cited. The main outcomes found for studies conducted in Brazil and Europe are described in tables 2 and 3, respectively.

Quality analysis

The quality assessment of the RCT studies is shown in Figure 2 and the analysis of observational studies is in Figure 3.

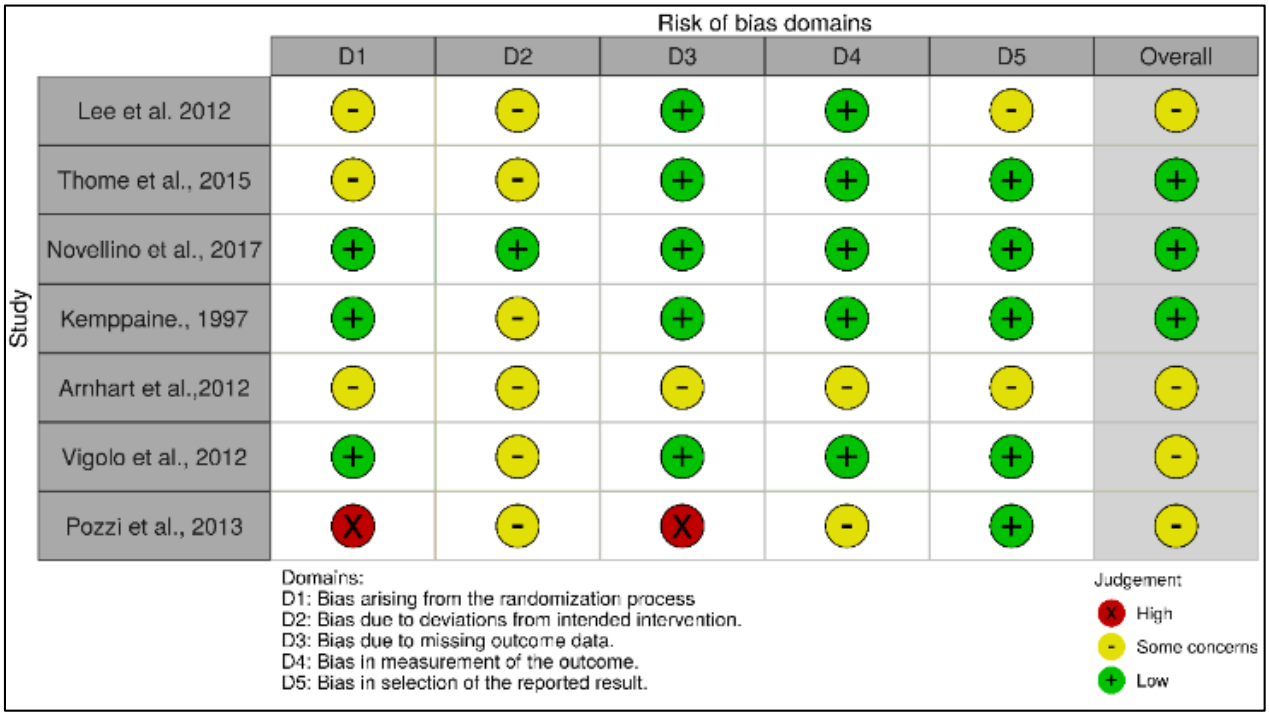

Fig 2: Summary of the risk of bias of included RCT studies according to ROB.

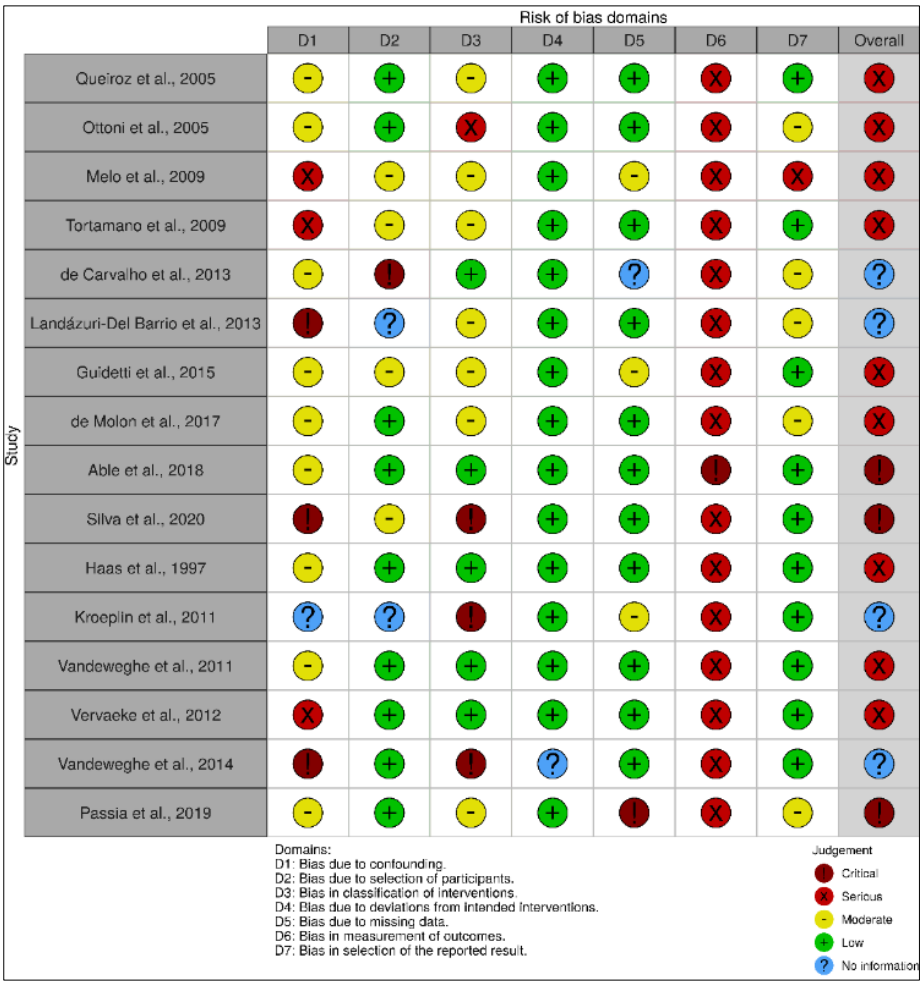

Fig 3: Summary of the risk of bias of included observational studies according to ROBINS-I tool.

Discussion

Prosthetic rehabilitation of edentulous patient with osseointegrated implants was first introduced by Branemark in 1965, and present several advantages like predictability and reliability especially when compared to removable prostheses [34, 35, 36]. Another favorable point of dental implants is high patient satisfaction reported by some authors, mainly regarding function, comfort and aesthetics [37,38,39]. Although dental implant industry has developed over the years, introducing different implant materials, titanium is still the gold-standard material for their production, due to its biocompatibility, resistance to corrosion and mechanical properties [6,40]. This leads to long-term implant survival and success that have been reported by many studies in different populations [41,42,43,44]. The aim of this study was to compare survival rates of osseointegrated dental implants placed in European and Brazilian individuals in order to verify the results´ applicability for different populations. Therefore, some of the exclusion criteria applied for study selection had the goal of eliminating potential confounding factors that might influence implant survival, other than ethnic characteristics. Those factors were uncontrolled systemic diseases, smoking habit, grafting procedures and other risk factors (i.e. periodontitis), as they have been reported to be related to implant failure [45,46,47,48,49].

Few differences were found between the two groups of studies with respect to follow-up period and patient´s mean age. The Brazilian studies maximum follow-up period was 5 years longer than the European ones. Regarding patients mean age, the studies conducted in Europe included younger subjects. Regardless of some studies not reporting or evaluating complications, bone loss and prosthesis fracture were the most reported by both Brazilian and European studies. The RCTs included were evaluated as presenting low or moderate risk of bias. Most issues were related to not presenting an adequate randomization process and to differences in interventions, which are factors often difficult to control in dental implant studies. On the other hand, observational studies, which are the most available study designs in the literature and in the present review, presented serious or critical risks of bias. This result is mainly explained by issues in the measurement of outcomes domain and the difficulty in controlling some Cofounding factors that cannot be totally, such as implant and surgery differences. Those, however, are not expected to play an important role in the outcomes of interest for the present review. Finally, within limitations due to the quality and heterogeneity of the included studies, our data suggest that very similar survival rates are observed for osseointegrated dental implants placed in patients of different ethnic origins (i.e. Brazilian and European), regardless of implant brand. Even though a study conducted in Brazil presented a very low survival rate of 56.6% [12], the authors suggested it was correlated with the application of immediate loading in implants presenting low primary stability (20 N.cm). The other studies presented survival rates ranging from 83.3% to 100%, while studies conducted in Europe showed 83.2% to 100% survival. Therefore, the very similar survival rates observed suggest that outcomes of studies on osseointegrated dental implants conducted in Brazil can be extended to European population, and vice-versa.

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