Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2024; 24:e230174
https://doi.org/10.1590/pboci.2024.070
ISSN 1519-0501 / eISSN 1983-4632

ORIGINAL ARTICLE

Cost-Effectiveness Analysis of Single-Tooth Rehabilitation Options

Manuel Henrique de Medeiros Neto[1], Rênnis Oliveira da Silva[1], Leopoldina de Fátima Dantas de Almeida[2], Edson Hilan Gomes de Lucena[2], Denise de Fátima Barros Cavalcante[3], Antonio Carlos Pereira[4], Yuri Wanderley Cavalcanti[2]

[1]Post-Graduate Program in Dentistry, Federal University of Paraiba, João Pessoa, PB, Brazil.
[2]Department of Clinics and Social Dentistry, School of Dentistry, Federal University of Paraiba, João Pessoa, PB, Brazil.
[3]Albert Einstein Israelite Hospital, São Paulo, SP, Brazil.
[4]Department of Social Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, SP, Brazil.

Corresponding author: Yuri Wanderley Cavalcanti **E-mail:** yuri@ccs.ufpb.br

Academic Editor: Wilton Wilney Nascimento Padilha

Received: August 28, 2023 / **Review:** December 08, 2023 / **Accepted:** January 15, 2024

How to cite: Medeiros Neto MH, Silva RO, Almeida LFD, Lucena EHG, Cavalcante DFB, Pereira AC, et al. Cost-effectiveness analysis of single-tooth rehabilitation options. Pesqui Bras Odontopediatria Clín Integr. 2024; 24:e230174. https://doi.org/10.1590/pboci.2024.070

ABSTRACT

Objective: To evaluate the cost-effectiveness of single-tooth rehabilitation options with dental implants associated with a prosthetic crown (I+C) compared to a fixed partial denture (FPD). **Material and Methods:** A rapid review was carried out to identify the costs (expressed in US$) and effectiveness (expressed through success rate). Bibliographic searches retrieved 1,447 records, of which 19 studies of type randomized clinical trials were selected to collect cost and effectiveness data. Markov economic models were used to simulate hypothetical 15-year cohorts with 2000 patients using cost and effectiveness data from the rapid review under the perspective of private practice. **Results:** The average costs of I+C and FPD treatments were US$ 3,432.23 and US$ 3,322.52, respectively. The average effectiveness of I+C was 88.33%, with a mean follow-up time of 9.33 years, and FPD had an average yearly success rate of 82.14%, with a mean follow-up time of 11.89 years. The I+C treatment has an incremental cost-effectiveness ratio (RCEI) of US$ 170.88 compared to FPD. **Conclusion:** Both I+C and FPD rehabilitation options are cost-effective; I+C rehabilitation has a higher cost and greater effectiveness, being the recommended option if the patient with no contraindication.

Keywords: Economics; Dental Prosthesis, Implant-Supported; Denture, Partial, Fixed.

Introduction

Tooth loss may restrict masticatory, psychological and social functions and, thereby, impact the quality of life and overall health of affected individuals [1]. While some individuals do not perceive tooth loss as a health issue [2], rehabilitation with three-unit fixed partial denture (FPD) and single-crown implant are often recommended [3].

Prior to the emergence of osseointegrated implants, FPD was the rehabilitation choice for single tooth loss for providing esthetic and predictable outcomes. However, the wear on abutment teeth required for FPD installation can compromise the pulp tissue to the extent that endodontic treatment and an intra-radicular retainer are needed. Therefore, teeth with a poor prognosis should be extracted and not incorporated into the FPD [4]. Moreover, supporting teeth are exposed to biological and technical risks, which include endodontic complications, secondary carious lesions, poor biofilm control, periodontal issues, loss of bone support, and teeth and denture fractures [5-7].

Single-tooth rehabilitation can be performed by installing an implant associated with a tooth crown. Implant-supported fixed dentures (ISFD) overcome the limitations of removable conventional dentures due to functional and psychological advantages for users [8]. Nonetheless, ISFD is regarded as the primary treatment choice for a healthy patient, and their associated biological risks (e.g., biofilm accumulation, peri-implant infection, etc.) remain recurrent [9].

The major advantage of implant-supported rehabilitation is the possibility of replacing the missing tooth without the need to wear teeth adjacent to the prosthetic space [10]. The patients' preference for implant-supported denture is significantly influenced by their socioeconomic condition. Patients with lower educational level and lower salaries are less likely to choose this rehabilitation option [11]. Although a high success rate and longevity of implant-supported denture has been reported [12-14], a comprehensive economic assessment is still needed to justify its indication from a cost-effectiveness standpoint.

Single-tooth replacement options remain a frequent source of uncertainty among practitioners and patients. In many cases, the choice for a given treatment is not based on scientific evidence or clear guidelines that can properly estimate the cost-effectiveness of the procedure [15]. The decision-making process should be based on parameters such as access to technology, professional expertise, patient preferences, as well as on the most current scientific evidence available from the literature [16].

Comprehensive economic assessments are critical to define the clinical protocol options and therapeutic guidelines as well as are issues related to patient satisfaction, treatment length, number of consultations, patient comfort, and preoperative and postoperative complications [5].

Previously, a systematic review of the literature examined some single-tooth rehabilitation alternatives [17]. The study demonstrated that implant-supported rehabilitation has greater longevity than FPD, so it is firmly established. However, the cost-effectiveness of both interventions remains unknown. Thus, the aim of our study was to compare the cost-effectiveness of ISFD and three-unit FPD for single-tooth replacement.

Material and Methods

Cost-Effectiveness Parameters – Systematic Search of the Literature

This rapid review of the literature was carried out in PubMed, Scopus and Web of Science databases using the descriptors "implant-supported dental prosthesis" and "fixed partial denture", and their synonyms. Table 1 present the search strategy and syntax used in each database. The PICO strategy (Population, Intervention, Comparator and Outcome) was adopted to compare the two rehabilitation approaches (I and C).

No search terms were defined for population (P) and outcome (O) to broaden the search records and retrieve potentially relevant studies.

Table 1. Search strategy for selection of studies in this scoping review.

Database	Descriptor and Boolean Operator
Pubmed	(((((((Dental Prosthesis, Implant-Supported[MeSH Terms]) OR Impant-supported dental prosthesis[Title/Abstract]) OR Implant Supported Dental Prosthesis[Title/Abstract]) OR Implant-Supported Dental Prostheses[Title/Abstract]) OR Implant-Supported Denture[Title/Abstract]) OR Implant Supported Denture[Title/Abstract]) OR Implant-Supported Dentures[Title/Abstract])) AND (((((((Denture, Partial, Fixed[MeSH Terms]) OR Fixed Bridge[Title/Abstract]) OR Fixed Bridges[Title/Abstract]) OR Fixed Partial Denture[Title/Abstract]) OR Fixed Partial Dentures[Title/Abstract]) OR Pontic[Title/Abstract]) OR Pontics[Title/Abstract])
Scopus	TITLE-ABS-KEY("Impant-supported dental prosthesis" OR "Implant Supported Dental Prosthesis" OR "Implant-Supported Dental Prostheses" OR "Implant-Supported Denture" OR "Implant Supported Denture" OR "Implant-Supported Dentures") AND TITLE-ABS-KEY("Fixed Bridge" OR "Fixed Bridges" OR "Fixed Partial Denture" OR "Fixed Partial Dentures" OR "Pontic" OR "Pontics")
Web of Science	TS=("Impant-supported dental prosthesis" OR "Implant Supported Dental Prosthesis" OR "Implant-Supported Dental Prostheses" OR "Implant-Supported Denture" OR "Implant Supported Denture" OR "Implant-Supported Dentures") AND TS=("Fixed Bridge" OR "Fixed Bridges" OR "Fixed Partial Denture" OR "Fixed Partial Dentures" OR "Pontic" OR "Pontics")

The search results were exported to a reference manager software (Mendeley Desktop, v.1.19.4) for the removal of duplicate records and to systematize the reading of titles and abstracts. Inclusion criteria consisted of Randomized Clinical Trials that compared ISFD against three-unit FPD by reporting costs of treatments and success rate. Upon preliminary screening, eligible studies were analyzed in full for data extraction and synthesis. The cost data extracted from the articles were used for the economic assessment of the interventions. Descriptors related to study outcomes were not included. Studies addressing the costs and effectiveness parameters were screening for eligibility based on the reading of the title and abstract and, later, full-text analysis.

Economic Assessment

A comprehensive cost-effective economic assessment was performed based on mathematical modeling, in accordance with the guidelines of the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) and the Brazilian Health Technology Assessment Network (REBRATS). This analysis considered the perspective of private professional practice based on international market values (expressed in US dollars). The model population used for the analysis consisted of a hypothetical cohort of 2000 patients with a single tooth missing in the anterior or posterior region. The number of patients was arbitrarily defined for model constitution purposes.

Two interventions were proposed, namely: (i) Rehabilitation with FPD, in which there is a need to wear teeth adjacent to the prosthetic space and to install a three-unit denture; (ii) Rehabilitation with a dental implant and a single crown (I+C), in which a dental implant is installed, and a total single crown is placed thereon.

A Markov model was developed to obtain long-term clinical and economic outcomes of the proposed interventions. The model was designed based on the comparison of both interventions, each consisting of two mutually exclusive health states: rehabilitated without complications - success (state A) and rehabilitated with complications - failure (state B). According to the assigned probabilities, patients may move between health states (A and B) or remain in the same health state at the end of the yearly cycle. A sensitivity analysis was performed from a hypothetical cohort simulation with 2000 patients, to which a yearly discount rate of 5% for costs, a 20% variation in parameters, and a 15-year time horizon were applied. The time horizon was intentionally overestimated due to the average longevity of the treatments. The yearly discount rate and the variation of the

parameters were based on other economic assessment studies [18,19]. The economic assessment model used in this study, considering the costs and effectiveness of both interventions, is available in Figure 1.

Information on treatment costs were extracted from the international scientific literature. Cost data reported in different countries were expressed in US dollars using the 2019 exchange rate. The treatment costs correspond only to out-of-pocket expenses, which include direct costs with treatment, materials, equipment and professional fees.

Effectiveness was defined in the model based on a literature search for intervention failure and success rates and years of success. The pyramid of scientific evidence on health was followed in order to choose the studies with the highest degree of evidence, which correspond to systematic reviews and meta-analyses.

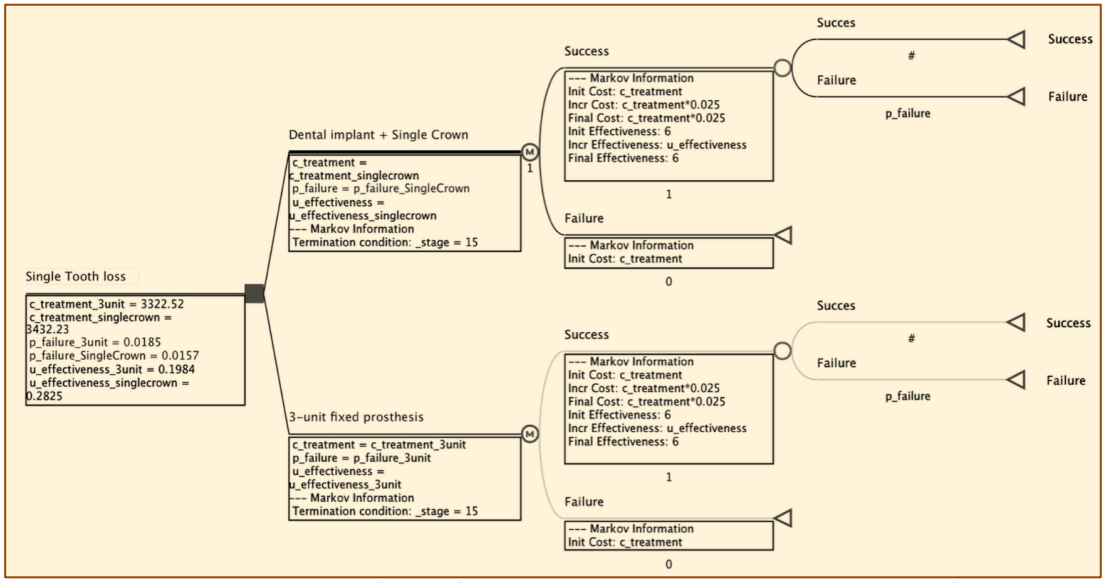

Figure 1. Economic evaluation model used for Monte Carlo micro-simulation, considering Markov's transient conditions, cost and effectiveness of two treatments over a 15-year time horizon.

The analysis was carried out using TreeAgePro Software (TreeAge Software, Version 2019 R1.2). The models were analyzed according to Monte Carlo microsimulation, and it was possible to generate dynamic tests and acceptability curves from the dynamic transitional Markov model. At the end of the analysis, it was possible to estimate the differences in the costs and effectiveness of the proposed interventions as well as the incremental cost-effectiveness ratios (ICER). The model was simulated considering a 20% variation of the distributions. The cost-effectiveness of the interventions was compared using the ICER parameter. Willingness to Pay (WTP) was set at the lowest cost under investigation. WTP consists of how much money the payer is willing to invest to access such technology. In this study, the lowest cost between FDP and I+C was set as WTP. Net monetary benefit (NMB) was calculated using the following formula: NMB = (Effectiveness * WTP) – Cost. The percentage of NMB gain was used to estimate the cost-benefit of adopting one of the two technologies.

Results

A total of 1,566 studies were retrieved, of which 119 were duplicate records and 1,417 did not meet the inclusion criteria. Thirty full-text articles were analyzed, of which eight were used to identify costs [5,10,20-25] and eleven to estimate the effectiveness of the treatments [3,10,17,20,21,26-31]. The effectiveness of the interventions was estimated based on success rates [10,17,20,21,26-29,31].

The average cost of single-tooth replacement with a dental implant and a prosthetic crown was US$ 3,432.23 as compared to US$ 3,322.52 with a three-unit FPD. Hence, both rehabilitation options are similar from a monetary point of view. Therefore, the cost of treatment should not be decisive for the patient's preference since the difference between the two technologies was only US$ 109.71 (relative to the means) or US$ 131.025 (relative to the medians) (Table 2).

Table 2. Costs (in US$) of single-tooth replacement with dental implant and prosthetic crown or three-unit fixed denture, according to eight selected studies.

Study	Cost (in US$) of Dental Implant with a Prosthetic Crown	Cost (in US$) of Three-Unit Fixed Denture
Brägger et al. [5]	3,192.46	3,908.13
Kim et al. [10]	2,162.00	1,556.50
Christensen [20]	3,289.00	2,614.00
Bouchard et al. [21]	3,978.68	4,960.62
Kim et al. [22]	4,170.60	3,605.41
Augusti et al. [23]	3,110.81	1,866.49
Zitzmann et al. [24]	5,797.11	6,379.41
Antonarakis et al. [25]	1,757.15	1,689.56
Mean	US$ 3,432.23	US$ 3,322.52
Median	US$ 3,240.73	US$ 3,109.705

The average yearly success rate of dental implant/prosthetic crown intervention was 88.33%, with a mean follow-up time of 9.33 years. The three-unit FPD intervention had an average yearly success rate of 82.14%, with a mean follow-up time of 11.89 years. The yearly success rates of dental implant/prosthetic crown and three-unit FPD were 0.2825 and 0.1984, respectively. These findings demonstrate that implant-supported rehabilitation has a success rate and a yearly success rate higher than those of the three-unit FPD (Table 3).

Table 3. Success rates and yearly survival of single-tooth rehabilitation options (dental implant and prosthetic crown or three-unit fixed denture).

Study	Effectiveness of Dental Implant with a Prosthetic Crown			Effectiveness of Three-Unit Fixed Denture		
	Success Rate	Follow-up Time (in years)	Yearly Success Rate	Success Rate	Follow-up Time (in years)	Yearly Success Rate
Kim et al. [10]	91.7%	10	0.2203	81.3%	10	0.1543
Torabinejad et al. [17]	95%	6	0.3930	81%	6	0.2417
Christensen [20]	95%	5	0.4507	84%	20	0.0875
Bouchard et al. [21]	92%	20	0.1186	69%	20	0.0568
Pjetursson et al. [26]	89.4%	10	0.2010	89.2%	10	0.1995
Salinas and Eckert [27]	95.1%	5	0.4529	94%	5	0.4303
Fugazzotto [28]	95.1%	5	0.4529	94%	5	0.4303
Incici et al. [29]	47%	8	0.0762	59%	16	0.0542
Walton [31]	94.64%	15	0.1772	87.79%	15	0.1308
Mean	88.33%	9.33	0.2825	82.14%	11.89	0.1984
Median	94.64%	8	0.2203	84%	10	0.1543

The rapid review data were used for cost-effectiveness analysis based on hypothetical Markov cohort modeling. The analysis showed that both rehabilitation options are somewhat equivalent. Implant-supported rehabilitation presented higher costs associated with greater effectiveness, considering the parameters of success rate. For greater success, one should opt for implant-supported rehabilitation, with an investment of US$ 170.88 required for each yearly increment of success (Table 4). The percentage of NMB gain (Table 4) shows that an implant-retained crown presents 9,45% more benefit compared to a three-unit fixed denture.

Table 4. Cost-effectiveness analysis of single-tooth rehabilitation. Cost and effectiveness values for rehabilitation options were applied to hypothetical cohorts with 2000 individuals, considering a 15-year time frame and 5% parameter variation. The Incremental Cost-Effectiveness Ratio (ICER) corresponds to the investment required to achieve the highest effectiveness value. Net monetary benefit (NMB) estimate the cost-benefit of adopting the alternative technology (dental implant and prosthetic crown).

Rehabilitation Option	Cost (in US$)	Incremental Cost (in US$)	Effectiveness (Yearly Success Rate)	Incremental Effectiveness (Yearly Success Rate)	Incremental Cost-Effectiveness Ratio (ICER)	Net Monetary Benefit (NMB)
Three-unit fixed denture	4,080.13		9.92		-	36,394.76 (reference)
Dental implant and prosthetic crown	4,230.14	150.01	10.80	0.88	US$ 170.88 / yearly success rate	39,835,26 (9,45% of NMB gain)

While implant-supported rehabilitation is more costly, it has been shown to be more effective. The investment required to achieve greater effectiveness is not considered high and may result in a greater overall benefit to the patient. Thus, if the patient can invest a little more in a more effective treatment, their overall benefit will be greater.

Figure 2 illustrate the cost-effectiveness analysis of the technologies used for single-tooth rehabilitation. The hypothetical cohorts generated random distribution data of cost and effectiveness measures for the two treatment options under analysis.

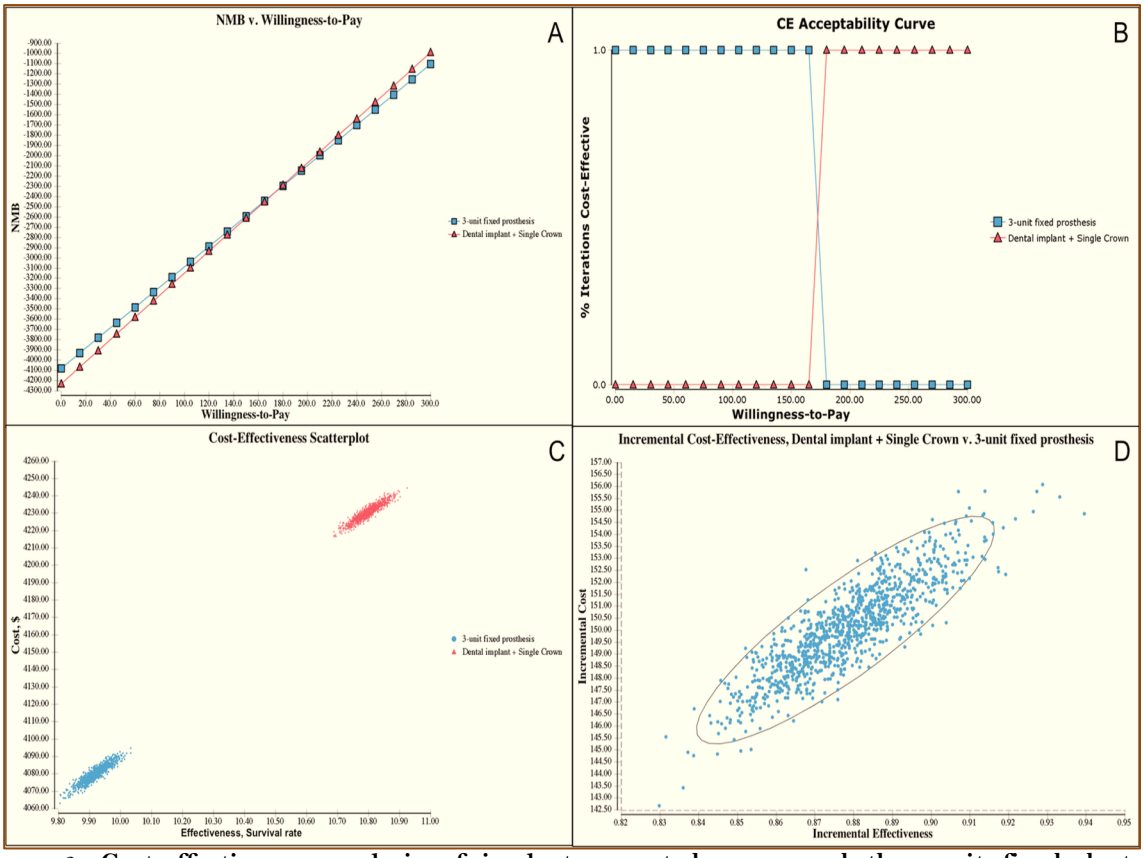

Figure 2. Cost-effectiveness analysis of implant-supported crown and three-unit fixed denture, considering the yearly success rate of the treatments as an outcome of effectiveness. Figure 2A illustrates the relationship between net monetary benefit (NMB) and willingness to pay. Figure 2B illustrates the acceptability curve according to willingness to pay. Figure 2C shows the random distribution of cost and effectiveness values for both technologies. Figure 2D illustrates the dispersion of incremental cost and effectiveness values of the implant-supported crown compared to the three-unit fixed denture. The ICER obtained for this analysis was US$ 170.88 per yearly success rate, which represents the average of the values obtained for Figure 2D and coincides with the intersection points viewed in Figures 2A and 2B.

Discussion

This study demonstrates that the costs of single-tooth rehabilitation with dental implant and three-unit fixed denture are similar. Our hypothetical cohort data showed that implant-supported rehabilitation is more costly and more effective than that with FPD. Based on the highest ICER identified in this study, an additional investment of 5.14% over the costs of rehabilitation with three-unit FPD may provide greater effectiveness for affording implant-supported rehabilitation. However, the latest cost data used in this study is from 2014; therefore, changes may have occurred over this time.

The parameters assigned in this study are based on data from the international scientific literature and consider the perspective of private professional practice. Only direct treatment costs reported within the included studies were considered. In the case of rehabilitation options, additional costs associated with endodontic therapy, bone graft surgery, or reconstruction of the abutment teeth were not considered. The present study analyzed a well-defined scenario in which a dentist and patient may decide between an FDP or an I+C treatment, regardless of any specific complementary treatment. Costs of treatments varied along the included studies and such values may have considered slight differences regarding treatments. Additional variations within the clinical protocol were not reported in the literature.

Rehabilitation with a three-unit FPD results in additional wear of teeth adjacent to the prosthetic space. The preparation of abutment teeth can be considered unnecessary when they do not present defective fillings or previous caries experience. In the present study, unnecessary wear of healthy dental tissue was not considered from a "biological cost" viewpoint. Although rehabilitation with FPD has possible additional costs and requires tooth preparation, a significant number of patients are concerned about surgical procedures and assume that implant-supported rehabilitation is more costly [21].

Overall, individuals with lower educational level and lower salaries tend not to opt for implant-supported fixed rehabilitation [11]. This aspect should be deliberated with the patient when making a clinical decision. According to the results, implant-supported rehabilitation has a slightly higher cost, but it also has greater effectiveness in terms of success rate, which should be pondered by the patient. The tooth to be rehabilitated and the patient's previous caries experience are also relevant factors for clinical decision making and willingness to pay [32].

In the clinical routine, the practitioner often has several single-tooth replacement options to offer. Commonly, the patient seeks a permanent and stable prosthetic solution. However, the practitioner is not always aware of the best option to choose from in terms of cost-effectiveness. Our findings indicate that both treatment options are acceptable and effective; however, implant-supported rehabilitation has greater cost-effectiveness. The patient's willingness to pay will determine the best effectiveness measures for implant-supported rehabilitation. Other aspects should also be considered, which include patient's health condition and willingness to undergo implant surgery. Although high survival rates of dental implants have been demonstrated in high-risk patients [12], implant placement in smoking patients with decompensated diabetes, poor hygiene and exposure to radiation therapy is not often recommended [33]. Therefore, cost-effectiveness analysis should not be the only parameter to be considered in treatment decision making. Moreover, the likely need for endodontic treatment and severe wear of the abutment teeth of a fixed denture should be weighted out according to the patient's health status, individual preferences and affordability to pay.

This study has some limitations to consider, since the theoretical analysis was based on other studies carried out in different countries with diverse socioeconomic, technological and cultural backgrounds. Nevertheless, the secondary source of cost and effectiveness information aimed to overcome the limitations

related to the external validity of the economic health assessments. The results of this study may vary in each country due to direct costs of rehabilitation, including professional fees, materials, inputs and taxes. Another possible source of variation consists of potential conflicts of interest of included studies. Potential selective reporting or evident conflict of interest were not detected within the included studies. However, this aspect should be recognized as a source of variation that would influence the results of the present study.

Further studies should be designed to consider the variations in rehabilitation strategies. The findings of our study may be influenced by different types of materials (e.g., metal-ceramic or metal-free crowns), implant installation techniques (e.g., immediate or late) and prosthetic crowns (e.g., screwed or cemented, over intermediates or straight over the implant platform), or need for endodontic treatment and preparation of an intra-radicular retainer for the prosthetic abutments. Our results are valid for an overall comparison of three-unit FPD and implant-supported crown, according to the international literature. Future clinical evaluations should include cost-effectiveness information, rather than just effectiveness data, to enable comparisons between different types of rehabilitation.

Conclusion

Single-tooth replacement with a dental implant and a prosthetic crown is more costly and more effective than that with a three-unit fixed denture. The choice for implant-supported rehabilitation is dependent on the patient's willingness to pay.

Authors' Contributions

MHMN	https://orcid.org/0000-0002-9514-532X	Conceptualization, Investigation, Resources, Data Curation and Writing - Original Draft.
ROS	https://orcid.org/0000-0001-8413-8071	Writing - Review and Editing.
LFDA	https://orcid.org/0000-0001-5997-6612	Writing - Review and Editing.
EHGL	https://orcid.org/0000-0003-3431-115X	Writing - Review and Editing.
DFBC	https://orcid.org/0000-0002-9166-0367	Methodology and Writing - Review and Editing.
ACP	https://orcid.org/0000-0003-1703-8171	Methodology and Writing - Review and Editing.
YWC	https://orcid.org/0000-0002-3570-9904	Conceptualization, Methodology and Supervision.

All authors declare that they contributed to critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] López CS, Saka CH, Rada G. Impact of fixed implant supported prostheses in edentulous patients: Protocol for a systematic review. BMJ Open 2016; 6:e009288. https://doi.org/10.1136/bmjopen-2015-009288

[2] Greenstein G, Greenstein B, Carpentieri J. The need to replace a missing second molar with a dental implant restoration: Analysis of a controversial issue. Compend Contin Educ Dent 2018; 39(1):686-693.

[3] Al-Quran FA, Al-Ghalayini RF, Al-Zu'bi BN. Single-tooth replacement: Factors affecting different prosthetic treatment modalities. BMC Oral Health 2011; 11:34. https://doi.org/10.1186/1472-6831-11-34

[4] Hemmings K, Harrington Z. Replacement of missing teeth with fixed prostheses. Dent Update 2004; 31(3):137-141. https://doi.org/10.12968/denu.2004.31.3.137

[5] Brägger U, Krenander P, Lang NP. Economic aspects of single-tooth replacement. Clin Oral Implants Res 2005; 16(3):335-341. https://doi.org/10.1111/j.1600-0501.2005.01112.x

[6] Brägger U, Hirt-Steiner S, Schnell N, Schmidlin K, Salvi GE, Pjetursson B, et al. Complication and failure rates of fixed dental prostheses in patients treated for periodontal disease. Clin Oral Implants Res 2011; 22(1):70-77. https://doi.org/10.1111/j.1600-0501.2010.02095.x

[7] Styranivska O, Kliuchkovska N, Mykyyevych N. Comparison of using differentbridge prosthetic designs for partial defect restoration through mathematical modeling. Eur J Dent 2017; 11(3):345-351. https://doi.org/10.4103/ejd.ejd_72_17

[8] Goodacre CJ, Naylor WP. Single implant and crown versus fixed partial denture: A cost-benefit, patient-centred analysis. Eur J Oral Implantol 2016; 9(Suppl 1):S59-68.

[9] Lee CT, Huang YW, Zhu L, Weltman R. Prevalences of peri-implantitis and peri-implant mucositis: Systematic review and meta-analysis. J Dent 2017; 62:1-12. https://doi.org/10.1016/j.jdent.2017.04.011

[10] Kim Y, Park JY, Park SY, Oh SH, Jung Y, Kim JM, et al. Economic evaluation of single-tooth replacement: Dental implant versus fixed partial denture. Int J Oral Maxillofac Implants 2014; 29(3):600-607. https://doi.org/10.11607/jomi.3413

[11] Leles CR, Dias DR, Nogueira TE, McKenna G, Schimmel M, Jordão LMR. Impact of patient characteristics on edentulous subjects' preferences for prosthodontic rehabilitation with implants. Clin Oral Implants Res 2019; 30(3):285-292. https://doi.org/10.1111/clr.13414

[12] De Angelis F, Papi P, Mencio F, Rosella D, Di Carlo S, Pompa G. Implant survival and success rates in patients with risk factors: Results from a long-term retrospective study with a 10 to 18 years follow-up. Eur Rev Med Pharmacol Sci 2017; 21(3):433-437.

[13] Albrektsson T, Donos N, Working Group 1. Implant survival and complications. The Third EAO consensus conference 2012. Clin Oral Implants Res 2012; 23(Suppl 6):63-65. https://doi.org/10.1111/j.1600-0501.2012.02557.x

[14] Schwarz S, Bernhart G, Eiffler C, Hassel AJ, Lehmann F, Rammelsberg P. Early loading of implants with fixed dental prostheses in edentulous mandibles: 7.2-year clinical results from a prospective study. Clin Implant Dent Relat Res 2014; 16(6):904-912. https://doi.org/10.1111/cid.12062

[15] Pennington MW, Vernazza CR, Shackley P, Armstrong NT, Whitworth JM, Steele JG. Evaluation of the cost-effectiveness of root canal treatment using conventional approaches versus replacement with an implant. Int Endod J 2009; 42(10):874-883. https://doi.org/10.1111/j.1365-2591.2009.01582.x

[16] Maia LC, Antonio AG. Systematic reviews in dental research. A guideline. J Clin Pediatr Dent 2012; 37(2):117-124. https://doi.org/10.17796/jcpd.37.2.h606137vj3826v61

[17] Torabinejad M, Anderson P, Bader J, Brown LJ, Chen LH, Goodacre CJ. Outcomes of root canal treatment and restoration, implant-supported single crowns, fixed partial dentures, and extraction without replacement: A systematic review. J Prosthet Dent 2007; 98(4):285-311. https://doi.org/10.1016/S0022-3913(07)60102-4

[18] Pereira AC, Bahia LR, Cavalcante DFB, Menehim MC, Cavalcanti YW, Ambrosano GMB, et al. Budgetary impact of oral rehabilitation with complete dentures: An economical evaluation from São Paulo State, Brazil. Value Health Reg Issues 2019; 20:73-78. https://doi.org/10.1016/j.vhri.2019.01.008

[19] Probst LF, Vanni T, Cavalcante DFB, Silva ET, Cavalcanti YW, Passeri LA, et al. Cost-effectiveness of implant-supported dental prosthesis compared to conventional dental prosthesis. Rev Saude Publica 2019; 53:S0034-89102019000100257. https://doi.org/10.11606/s1518-8787.2019053001066

[20] Christensen GJ. Three-unit fixed prostheses versus implant-supported single crowns. J Am Dent Assoc. 2008 Feb;139(2):191-4. doi: 10.14219/jada.archive.2008.0136. PMID: 18245688.

[21] Bouchard P, Renouard F, Bourgeois D, Fromentin O, Jeanneret MH, Beresniak A. Cost-effectiveness modeling of dental implant vs. bridge. Clin Oral Implants Res 2009; 20(6):583-587. https://doi.org/10.1111/j.1600-0501.2008.01702.x

[22] Kim SG, Solomon C. Cost-effectiveness of endodontic molar retreatment compared with fixed partial dentures and single-tooth implant alternatives. J Endod 2011; 37(3):321-325. https://doi.org/10.1016/j.joen.2010.11.035

[23] Augusti D, Augusti G, Re D. Prosthetic restoration in the single-tooth gap: patient preferences and analysis of the WTP index. Clin Oral Implants Res 2014; 25(11):1257-1264. https://doi.org/10.1111/clr.12264

[24] Zitzmann NU, Krastl G, Weiger R, Kühl S, Sendi P. Cost-effectiveness of anterior implants versus fixed dental prostheses. J Dent Res 2013; 92(12 Suppl):183S-188S. https://doi.org/10.1177/0022034513504927

[25] Antonarakis GS, Prevezanos P, Gavric J, Christou P. Agenesis of maxillary lateral incisor and tooth replacement: Cost-effectiveness of different treatment alternatives. Int J Prosthodont 2014; 27(3):257-263. https://doi.org/10.11607/ijp.3851

[26] Pjetursson BE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. Clin Oral Implants Res 2012; 23(Suppl 6):22-38. https://doi.org/10.1111/j.1600-0501.2012.02546.x

[27] Salinas TJ, Eckert SE. In patients requiring single-tooth replacement, what are the outcomes of implant- as compared to tooth-supported restorations? Int J Oral Maxillofac Implants 2007; 22:71-95.

[28] Fugazzotto PA. Evidence-based decision making: Replacement of the single missing tooth. Dent Clin North Am 2009; 53(1):97-129. https://doi.org/10.1016/j.cden.2008.10.001

[29] Incici E, Matuliene G, Hüsler J, Salvi GE, Pjetursson B, Brägger U. Cumulative costs for the prosthetic reconstructions and maintenance in young adult patients with birth defects affecting the formation of teeth. Clin Oral Implants Res 2009; 20(7):715-721. https://doi.org/10.1111/j.1600-0501.2009.01711.x

[30] Swelem AA, Gurevich KG, Fabrikant EG, Hassan MHA, Aqou S. Oral health-related quality of life in partially edentulous patients treated with removable, fixed, fixed-removable, and implant-supported prostheses. Int J Prosthodont 2014; 27(4):338-347. https://doi.org/10.11607/ijp.3692

[31] Walton TR. An up-to-15-year comparison of the survival and complication burden of three-unit tooth-supported fixed dental prostheses and implant-supported single crowns. Int J Oral Maxillofac Implants 2015; 30(4):851-861. https://doi.org/10.11607/jomi.4220

[32] Leung KC, McGrath CP. Willingness to pay for implant therapy: a study of patient preference. Clin Oral Implants Res 2010; 21(8):789-793. https://doi.org/10.1111/j.1600-0501.2009.01897.x

[33] Chen H, Liu N, Xu X, Qu X, Lu E. Smoking, radiotherapy, diabetes and osteoporosis as risk factors for dental implant failure: a meta-analysis. PLoS One 2013; 8(8):e71955. https://doi.org/10.1371/journal.pone.0071955