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Micro gap at Implant abutment Connections - A Systematic Review

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Abstract

Introduction: implant supported has a mesostructure that is tightly attached to the bone and an abutment that supports the superstructure are the main components of a typical implant. The presence of a micro gap at the implant-abutment contact is a clinical problem with connection geometry because most implants fail at the site of connection. As in the traditional Branemark method, the fixture is given time to integrate before the prosthetic connection between the abutment and the restoration is completed. Bacteria that cause the bone around the connection to deteriorate may be present in this gap.

Objective: The purpose of this systematic review was to evaluate the presence of gap and various agents used to stop in various implant abutment connections.

Methodology: From January 2006 to December 2022, dental literature was searched in the PubMed, PMC, Medline, EBSCOhost, and Google Scholar databases in accordance with the PRISMA Statement. There were 1058 papers found in the literature search, 852 of which were sorted for abstract reading,206 article selected for full text reading and 15 of the articles that met the inclusion criteria were included in the review. The final 15 articles were chosen, and three of them had an intervention like MPI's Moleculock, an antimicrobial polysiloxane coating that was factionalized with chlorhexidine digluconate (abbreviated as PXT).

Results: Final 15 studies selected after full text reading yielded that there is a micro gap existing between implant and abutment connection. Study by Sg Gherke [12] concluded that Morse taper show more gap after cyclic loading. The unloaded Morse taper connection showed 3.34 µ and the loaded condition showed 1.9 µ. Tanja [16] studied internal hexagon connection with a load of 200N with increments of 10N showed horizontal gap of 59.93 µ and vertical gap of 30.82 µ. Thus a vertical gap constitutes less than horizontal gap. Study by Sergio Alexandre [18] showed that conical connections showed gap of 8.9 µ when loaded at 25N. A study by Sg Gherke[17] in 2017 showed that the external hexagon connection has a gap of 15.3 µ at 150N of cyclic loading. Zipprich studied 6 butt connection type of implant and concluded 15.2 µ of gap exists when loaded at 25N incrementing up to 200N load.

Conclusion: The study found that all implant abutment connections have micro gaps that allow microorganisms to grow, and numerous studies have been done to reduce these gaps. Different authors used a variety of materials at the junction, and the results showed that the colony-forming unit of microorganisms also decreased.

Keywords: micro gap, implant abutment connection, microorganism, bone loss, Implant superstructure, Periimplantitis.Thiyaneswaran N[1], Rahul B, Surbala Devi, Mutum Sangeeta Devi, Sahana Selvaganesh

INTRODUCTION:

Implants have become more common in rehabilitation of partial or complete edentulous state. Success rate of implant has been tabulated as 90% which is mainly due to predictable outcome of osteo integration. [1] Traditional branemark system consisted of an endo structure which is anchored to the bone and also meso structure we supported a superstructure that is Prosthesis. [2]

Traditionally this type of system employees 2 stage where implant body is connected with prosthesis with an abutment. Now this connection can be established externally or internally with the implant body, this type of connection should process good integrity both mechanically and biologically because this junction has shown bone loss around it.[3] now this bone loss can be due to Mechanical stress around the connection or the misfit of the apartment and implant body. However the initial fixture may be good or marginal intact but due to mechanical stress the 2 parts may give a micro gap which may result in Flow of microorganism or inflammatory cell which may cause deteriorating effect such as bone loss around the junction.

Over the period modification is done to overcome this situation initially external hex conversion used in Branemark system later system developed into internal conical connection and internal hex connection also systems were developed to provide more hermetic seal which is a friction fit module. Because the majority of implants fail at the connection area, the presence of a micro gap at the implant – abutment interface is a clinical issue in terms of connection geometry.[4]

Binon [5] stressed the need of a proper fit between implant components, claiming that mismatch leads to repeated screw loosening, permanent screw fracture, and osseointegration damages. Abutment, which generates a micro gap that serves as a bacteria trap, resulting in peri-implantitis and mucositis, as well as bone loss and the "micro pump effect" axial tensions, resulting in passive adaptation between the prosthesis and the surrounding environment.[678]

The size of the micro gap at the implant–abutment contact has been studied in several investigations, and the average micro gap is about 50 micrometers. Martin – Gili et al. looked at fluid leaks and micro gaps in the internal and external connections of screw type abutments before and after occlusal load. The average micro gap in the internal connection was 2.34m after occlusion loading, and 4.14m in the external connection. [9] This gap might harbor microorganisms, resulting in peri-implant bone loss surrounding the loss. Sealant materials implant cavity cleaning, and other methods to minimize or reduce bacterial contamination at the implant-abutment interface have all been recommended. [10, 11] this systematic review is done to evaluate the gap at implant abutment connection.

METHODOLOGY

Research question

Research question of this study was formulated which is "does a micro gap exist at implant abutment connection which can influence the marginal integrity of connection?" After research question formulation title was established and electronic search for any similar study was conducted on INPLASY International Platform of Registered Systematic Review and Meta-analysis Protocols

Formulation of criteria

After establishing the research question inclusion exclusion criteria were established for literature search. The inclusion criteria were used to identify which papers should be reviewed in this systematic review. Only articles that were published or approved between January 2006 and December 2021 were considered. In vitro with abstracts and full text papers published in English were selected. Review papers and case studies were not included in the study. (Table-1)

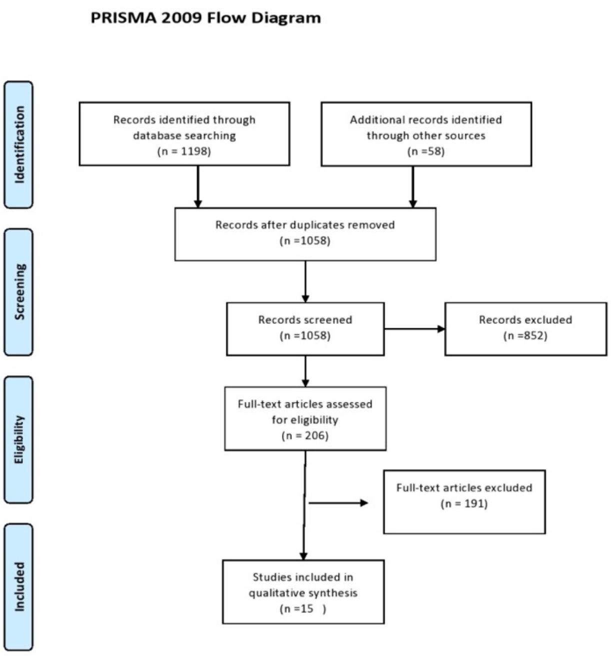

Figure 1-PRISMA flow diagram

Inclusion criteria:

1. Study published in an international peer-reviewed journal
2. Study published in English
3. Study with an involved minimum no. of implants 10
4. Study with multiple abutments systems

Exclusion criteria:

1. In vivo study, animal study, retrospective studies, case series or case Reports
2. Study published prior than 2006
3. Non-comparative studies.

Search strategy

Data collection

After establishment finding research question and formulation criteria search strategy is esblished where 4 reviewer are selected and data extraction was done by filling a table with following data that is authors name and year, numbers of samples, number of groups, types of connection, intervention, setup and results. Reviewers were instructed to fill the table after reading the articles.

Search Strategy

Dental literature was searched in the pub med, PMC, Medline, EBSCO host, and Google scholar databases From January 2006 to December 2021. The literature search was restricted to English-language peer-reviewed journals. The key words searched for this review were micro gap at implant abutment junction, gap at IAC, Marginal integrity of abutment connection. A manual as well as electronic search was done to select the relevant articles.

Results

Study selection

The literature search yielded 19198 papers, after removal of duplication 1058 articles retrieved for abstract reading. after abstract reading 852 articles were removed due to non-compilation with criteria and 206 articles retained for full text reading out of which 191 articles did not met the eligible criteria and 15 articles met the inclusion criteria and which were included in the review. A brief summary presenting invitro studies author and year, no. Of implants, connection type, load/torque/time, pertaining to implant abutment connection and their values tabulated in table 1.

RESULTS

Final 15 studies selected after full text reading yielded that there is a micro gap existing between implant and abutment connection. Study by Sg Gherke [12] concluded that Morse taper show more gap after cyclic loading. The unloaded Morse taper connection showed 3.34 µ and the loaded condition showed 1.9 µ. Tanja [16] studied internal hexagon connection with a load of 200N with increments of 10N showed horizontal gap of 59.93 µ and vertical gap of 30.82 µ. Thus a vertical gap constitutes less than horizontal gap. Study by Sergio Alexandre [18] showed that conical connections showed gap of 8.9 µ when loaded at 25N. A study by Sg Gherke[17] in 2017 showed that the external hexagon connection has a gap of 15.3 µ at 150N of cyclic loading. Zipprich studied 6 butt connection type of implant and concluded 15.2 µ of gap exists when loaded at 25N incrementing up to 200N load. (Figure-1)

Table-1 Summary presenting invitro studies

Author and year	No. Of implants	Connection type	Load/torque/ time	Results	MACHINE USED	CONCLUSION
TATJANA 2013	12	MORSE TAPER (ANKYLOS) CONICAL (ANKYLOS PLUS)	30N/90^0-12 100N/90^0-24 200N/30^0-22 30N/90^0-32 100N/90^0-36 200N/30^0-25	CONICAL CONNECTION SHOWED INCREASED MICROGAP HIGHEST MICRO GAP WAS 11 µ	SYNCHROTRON RADIOGRAPHY	CONICAL CONNECTION SHOWED INCREASED MICROGAP
SG GHERKE 2014	12	MORSE TAPER	UNLOADED 60N-1.35 LOADED 60N-3.34	UNLOADED-3.34µ LOADED-1.9µ	SCANNING ELECTRON MICROSCOPE	MORSE TAPER SHOWED INCREASED MICRO GAP AFTER CYCLIC LOADING
KAI BLUM 2015	12	CONICAL CONNECTION	ANKYLOS-6 NOBEL -12 ASTRATEC-12	MIGROGAP EXIXED IN ALL SPECIMEN ASTRATEC SHOWE LEAST WITH 6µ	SCANNING ELECTRON MICROSCOPE	. ALL IMPLANTS EXHIBIT A MICROGAP BETWEEN THE IMPLANT AND ABUTMENT PRIOR TO LOADING. THE GAP SIZE INCREASED WITH CYCLIC LOADING WITH ITS CHANGES BEING SIGNIFICANTLY HIGHER WITHIN THE FIRST 200,000 CYCLES
Daniela 2016	16	Conical-osseo speed Morse taper-dentsply	200 ncm load	2 µm -bottom of the iac and 20 µm at the implant collar	Micro-ct	A maximal gap width of 10 µm between the implant and abutment could be Predicted for a specific system under an oblique load Of 200 n
TANJA 2017	10	INTERNAL HEXAGON (ALFA GATE)	200 NCM WITH INCREMENTS OF 10NCM	HPRIZONTAL GAP-59.93 µ VERTICAL GAP-30.82µ	STERIOMICROSCOPE	VERTICAL AND HORIZONTAL GAP FORMATION IN ALL SAMPLES
SG GHERKE 2017	120	MORSE TAPER EXTERNAL HEXAGON INTERNAL HEXAGON	150 N CYCLIC LOADING	TRANSVERSE CUT- MORSE TAPER-13 µ EXTERNAL HEXAGON-15.3 µ INTERNAL HEXAGON-13.8 µ	SCANNING ELECTRON MICROSCOPE	MORRSE TAPER SHOWED LESS GAP COMPARED TO OTHER OTHER CONNECTIONS
Sergio alexandre 2016	40	Conical internal connection	Group 1 (g1), 25 ncm torque Group 2 (g2), 30 ncm torque Group 3 (g3), 35 ncm torque Group 4 (g4), 40 ncm torque	Group 1- 8.9µ Group 2-7.8µ Group 3-1.9µ Group 4 -0.3µ	Scanning electron microscope	With a higher torque, the linear area of contact between implant and abutment increases, reducing the gap between the pieces.
Biscoping2018	80	Conical internal connection 40 bego implants 40 nobel biocare implants	35 ncm Sealants • Silicone keiro seal • 1% chx gel • Beru temp	Bego implants • Control-53.84 µ • 1% chx gel-53.69 µ • Beru temp -53.82 µ Nobel biocare implants • Control -104.59 µ • 1% chx gel-105.97 µ • Keiro seal • -104.89 µ • Beru temp -103.69 µ	3d microscope	Beru temp showed less gap compared to silicone that is keiro seal
Zipprich 2018	20	Conical in 13 systems Butt connection in six systems Gable-like in one system	Sstarting at 25 n and ending at 200 n	Highest gap Conical-18.6µ Butt connection-15.2µ	Two-dimensional radiographs	Both, conical and butt connectionimplants, static loading caused greater dislocations of the abutments than the dynamic load in the identical experimental setup with the same force vector

Author and year	No. Of implants	Connection type	Load/torque/ time	Results	MACHINE USED	CONCLUSION
YITING HE 2019	20	GROUP A -10 SETS OF INTERNAL CONICAL CONNECTION GROUP B -10 SETS OF EXTERNAL HEXAGONAL CONNECTION	CONCENTRATED LOAD RANGING FROM 10 TO 100 N AT INTERVALS OF 10 N, AND FROM 120 TO 220 N AT INTERVALS OF 20 N WERE APPLIED AT 30 DEGREE TO THE IMPLANT'S LONG AXIS	GROUP A- 1.8µ GROUO B-2.9µ	MICRO-CT	THE CONICAL CONNECTION SHOWED MORE RESISTANCE AGAINST FORMATION OF MICRO-GAPS AT THE IMPLANTABUTMENT INTERFACE THAN THE EXTERNAL HEXAGONAL CONNECTION
Carnovale f 2020	20	Morse-type conical connections	Fib abrasions	Cross section - 0.97 ± 0.21µ Longitudinal sections- 1.23 ± 0.49µ	Scanning electron microscope	The present analysis clearly demonstrated the presence of a minimum gap that can promote the access of microorganisms
Sergey 2021	12	Internal conical connection	Cyclic loading upto 200 n Cylindrical sleeve as intervention	Mean gap was 2.9µ with out sleeve Mean gao was 0.3 µ with sleeve	Micro ct	Metal sleeve reduced micro gap
Aimen bagegni 2021	12	Butt-joint connection Internal conical connection	Computer-controlled dual-axis chewing simulator	Prior to chewing simulation, a microgap range between 0.26 µm and 0.52 µm was detected in the conical connection group, whereas the internal butt-joint connection group exhibited a microgap range between 0.26 µm and 0.47 µm. After chewing simulation,	Synchrotron-based µct	There is a microgap independent of the implant-abutment connection design.
Eduardo 2018	12	Nobel biocare Ankylos Neodent Conexão	30 ncm torque	The neodent system had the highest mean microgap values (5.84 ± 9.83 µm), followed by the nobel biocare systems (5.17 ± 4.10 µm), ankylos (3.47 ± 3.28 µm), and conexão (2.72 ± 3.19 µm)	Scanning electron microscope	All implant systems tested showed evidence of maladaptation at the iai, conformational error of the inner wall of the implant
Antonio scarano 2016	20	10 internal hexagon abutment (group i) and 10 had a cone morse taper internal connection (group ii)	30 ncm torque	Group i (implants with internal hexagon abutment) micro-ct images reveal microgap at a resolution of 9.7mm. Numerous gaps (mean 6.3 2.5mm) were present Group ii (implants with conical abutment) micro-ct images did not reveal microgap at a resolution of 9.7mm.	Micro ct	Implant-abutment misfit is known to increase mechanical stress on connection structures and surrounding bone tissue.

DISCUSSION:

Over time, implants with connection types other than external hexagonal have been developed with the hopes of reducing the biomechanical and biological issues that cause peri implant bone loss, enhancing the transfer of occlusion load to the implant and bone, and minimising micro-gaps at the implant-abutment interface to lessen bacterial colonisation. Some authors contend that conical connections, which result in "cold-welding," can be used to attain these objectives.[27, 28, 29]

Prior to and during occlusal loading, Martin-Gili et al.[30] looked at fluid leakage and micro gaps in both internal and external connections of screw-type abutments and found that the gap would enlarge as the number of mechanical cycles increased due to titanium alloy deformation. Different implant-abutment interactions react differently to functional loading. This may cause a range of peri-implant tissue reactions in addition to a range of technical issues this is in context in this Study by Tatjana et al showed increase in gap at higher loadings cycles.

Occlusal loading may result in micro-movements or bending forces inside the implant system. Cyclic loading has been demonstrated to enlarge the micro gap at the implant-abutment contact in various studies.[31,32,34] Bacteria can enter the hollow sections of the implant assembly due to the gap opening's due to micro-pump effect. in this review study by Tatjana el demonstrated micro gap formation increased when loading for was increased from 30N to 100N. A study by Daneila et al in this review demonstrated that 2µ existed at implant abutment connection and at implant collar it was 20µ pointing towards the clinical scenario of initial bone loss at implant collar.

Study by Fu JH et al [35] showed Morse taper and external hexagon demonstrated less organism leakage in Morse taper than external hexagon. In this review study by Antonio scarano demonstrate the same statement about the microgap.all the study Conical and more-taper connections produce better results, which may be attributable to their alleged biomechanical advantages. Various in vitro studies have demonstrated how conical abutments can reduce micro-gaps, if not completely remove them, and minimise micro-movements during loading.

It has been recommended to use shape memory alloys, clean the implant's interior chamber, and apply sealant materials to prevent or reduce gap at the implant-abutment interface. Platform switching is an idea that was developed by Lazzara and Porter. The implant-abutment contact has been recommended to be sealed with adhesive, a silicone O-ring, a silicon hermetic washer, chlorhexidine-thymol varnish, and a 2 percent chlorhexidine solution, sealing agents [36,37], Duarte et al. investigated the microbiological leakage on five different connections and discovered that Cervitec Varnish has the ability to close the micro gap and reduce micro leakage. [38] Gap seal is an effective sealer, according to Zarbakhsh et al evaluation of its ability to reduce micro gaps and micro leakage at the implant-abutment interface. The effectiveness of Gap seal and O-ring as sealing materials was also tested by Nayak et al. They came to the conclusion that Gap seal can lessen microgaps and micro leakage. [36, 37, 38]

Quality assessment of selected studies

Search was carried out by 4 independent examiners and possible causes of bias were addressed by focusing on the following criteria: random sequence generation and allocation concealment (both accounting for selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment. (Detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias).Modified CONSORT checklist for in vitro studies for establishing the quality assessments of the study reported in table-2.

CONCLUSION

The study found that there are microgao in all kinds of connections, and numerous studies have been done to reduce them. Since all of these studies were conducted in vitro, a strong in vivo study is necessary to draw the conclusion that these various interventions can reduce micro gaps clinically and reduce the gap, which reduces per implant inflammation and bone loss around the implant abutment connection. Various author used various types of material at the junction, and the results showed that these micro gaps were reduced. Further studies are required to analyze correlation between these micro gaps and clinical perception of the same.

Conflict of interest- nil,
Funding-This research received no external funding

Author	Abstract	Introduction		Methods			Results	Discussion	Other		Result
	1	2a	2b	3	4	5	6	7	8	9	
Tatjana 2013	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
SG GHERKE 2014	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Kai Blum 2015	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Daniela 2016	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
TANJA 2017	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	9/10
SG GHERKE 2017	YEaS	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Sergio Alexandre 2016	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	9/10
Biscoping2018	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Zipprich 2018	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Yiting He 2019	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Carnovale F 2020	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Sergey 2021	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Aimen Bagegni 2021	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	9/10
Eduardo 2018	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10
Antonio Scarano 2016	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	10/10

TABLE- 2 Results of the quality assessment of selected articles using the modified CONSORT checklist for in vitro studies

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