INFLUENCE OF DIFFERENT IMPLANT ABUTMENT CONNECTION DESIGNS ON ABUTMENT SCREW LOOSENING IN DENTAL IMPLANT SYSTEMS – A SYSTEMATIC REVIEW.

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Abstract

Background: Dental implants have provided an alternative method of prosthetic rehabilitation with high long-term success rates. However, mechanical or biological complications may occur with implants amongst which loosening of the screw is very common. Loosening of the screw might cause misfit of implant–abutment interface and may occur due to preload loss subsequent to inadequate initial torque, distortion of the screw, wear of the screw, overloading, and micro-movements because of functional loading. The implant-abutment connection design like internal hex, external hex and morse taper may affect the screw stability. The effect of various implant-abutment connections on the stability of abutment screw has been discussed in this systematic review.

Aim: The aim of this review is to assess and compare effect of different abutment connections on loosening of the screw.

Data Sources: An online search was made for the articles using Google Scholar and PubMed.

Study Eligibility Criteria: Articles published in English language or those articles that have a detailed summary in English language were included. Articles published between 1st January 2000 and 30th September 2018 was selected. Scientific research papers, Randomized controlled trials were included with data on the effect of various implant abutment connections on the loosening of the screw.

Results: Out of 449 articles that were identified through electronic database searching, 19 articles were selected. These articles were screened for duplicates and 7 articles were obtained after eliminating the duplicates. None were excluded after screening of the duplicate articles. This review provides an understanding of effect of various abutment connections on loosening of the screw.

Limitations: Few articles do not give concrete conclusions due to smaller sample sizes, differences inter-study sample population, variety of groups compared.

Conclusions: Out of all studies that were evaluated few stated that internal hex connection design had least screw loosening compared to external hex and morse taper while the other studies were inconclusive.

Keywords: Dental Implant, Implant-Abutment Connection, Screw Loosening

Introduction:

The screw is a crucial part of implant prosthesis. Screw loosening might cause displacement of prosthesis leading to loss of function.¹ It may also cause misfit of implant abutment interface,² causing bio-mechanical complications like microleakage of bacteria, fractures of the screw and/or the framework.³ Screw loosening may occurs due to inadequate preload, loss of preload subsequent to inadequate...
initial torquing, deformation of screw, wear of the screw, over-loading, and micro-movements due to functional loading. Various designs of implant abutment connection have been put forth to reduce the microgap.

Incidents of screw loosening are more common with single-tooth implant restorations. However, it occurs in multiple-unit cases as well.

A tight screw connection can be maintained by including anti-vibrational threads, mechanical interlocks, changing the design and mechanism of the screw to control torque.

These methods help in minimizing the screw loosening problem. However, they don't eliminate the problem completely.

Various implant–abutment connections that have been proposed include - External Hexagon, Internal Hexagon, and Conical or Morse Taper.

Screw loosening in immediate implant loading cases might transfer harmful stresses to the alveolar bone before osseointegration, thus causing failure of the osseointegration.

METHODS
ELIGIBILITY CRITERIA:

Inclusion Criteria:
1. Articles that are in English language or the articles that can be translated to English.
2. All full text articles.
3. Articles mentioning implant/abutment connections.
4. Scientific research papers, Randomized controlled trials with data on implant abutment connections and abutment screw loosening.

Exclusion Criteria:
1. Articles that are in a language other than English.
2. Articles with full text not available.
3. Review articles.
4. Letters to editors
5. Case reports.

PCOS:

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Different Implant Abutment connections</td>
</tr>
<tr>
<td>Comparison</td>
<td>Endosteal implants with implant abutment connections - Internal Hex, External Hex, Morse Taper, Internal conical</td>
</tr>
<tr>
<td>Outcome</td>
<td>Screw loosening</td>
</tr>
<tr>
<td>Study Design</td>
<td>Randomized controlled trials</td>
</tr>
</tbody>
</table>

INFORMATION SOURCES:
PubMed and Google scholar were the two databases used to complete the search for all full text articles available. Lists of the cross reference of the selected articles were checked for papers that might meet the eligibility criteria of the study. The search was done for studies published from 1st January 2000 to 30th September 2018.

SEARCH STRATEGY:
The comprehensive data search was done on PubMed and Google scholar. Articles published from January 1st 2000 till September 31st 2018 were included. Articles in English language were selected. Filters for full text and for study designs were not applied. The keywords used for searching articles in PubMed are given in table 1.

Table 1: Search Strategy

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Search Strategy</th>
<th>Total Number of Articles</th>
<th>Number of Selected Articles</th>
<th>Number of articles after duplicate removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implant abutment AND implant abutment connection design AND screw loosening</td>
<td>59</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Implant abutment connection OR implant abutment attachment OR implant abutment Joint AND screw loosening</td>
<td>92</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Implant abutment connection OR implant abutment Fixture OR implant abutment interconnection AND screw loosening</td>
<td>72</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Implant abutment connection AND screw loosening OR screw detachment OR screw disconnection</td>
<td>144</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Implant abutment connection AND screw loosening OR screw disconnection</td>
<td>80</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>Others</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>449</td>
<td>19</td>
<td>7</td>
</tr>
</tbody>
</table>
PRISMA 2009 Flow Diagram

Records identified through database searching (n=447)

<table>
<thead>
<tr>
<th>PRISMA 2009 Flow Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional records identified through other sources (n =2)</td>
</tr>
</tbody>
</table>

Total records (n =449)

Titles screened (n =449)

Records excluded after review of titles (n = 424)

Titles screened for duplicate removal (n=25)

Excluded-duplicates (n =12)

Abstracts screened (n=13)

Records excluded after review of abstracts (n =6)

Full texts screened on basis of title and abstract (n=7) (n=)

Studies excluded after review of full text (n=0)

Studies included in qualitative synthesis (n =7)
SEARCH ENGINES
Pub Med, Google Scholar, Institutional Library

STUDY SELECTION:
All articles were searched using the above mentioned search strategy. For screening of articles, initially, titles and abstracts were used to identify full articles concerning the effect of various connection designs on abutment screw loosening. After the articles were identified, duplicates from the respective searches were removed. In the final step, these articles were subjected to exclusion and inclusion criteria for the review.

Data was extracted independently by first author and the data extraction was confirmed by other review authors. Any difference of opinion between the reviewers was resolved with discussion. After this a data extraction sheet was prepared.

DATA COLLECTION PROCESS:
Significant data from the selected articles was recorded for screw loosening depending on connection design. A standard pilot form in excel sheet was used. Data extraction was first done for one of the selected articles according to the form and was evaluated by an expert and finalized. Data extraction was then done for all the remaining articles.

DATA ITEMS:
Selected articles were read thoroughly and the data was segregated under the following headings in an excel sheet.

1. Study ID – Serial number.
2. Author – Author name.
3. Publication Year – When the article was published.
4. Location – Where the study was conducted.
6. Sample Size of implants – Number of implants placed.
7. Brand Of Implant
8. Method of Loading – the method used for loading of implant
9. Outcome Assessment – the value measured after loading of implant.
10. Outcome – Amount of torque loss that occurred
11. Results - Which group had the highest screw loosening.
13. Other Observations

STUDY SELECTION:
The guidelines in PRISMA statement (Preferred Reporting Items for systematic Reviews and Meta-analysis) were followed for the systematic review. (Flowchart 1)

Preliminary screening consisted of 449 studies. The studies were screened and 430 studies were excluded for not meeting the eligibility criteria. Out of the remaining 19 studies, 12 were removed for being duplicates. Out of the remaining 7 studies, none were excluded after reading the abstract. Thus, total 7 studies were included in qualitative synthesis.

DISCUSSION
Several studies have been conducted to assess the effect of different implant abutment connection designs such as internal hexagon, external hexagon and morse taper on screw loosening. This systematic review has been attempted to find the best available evidence to determine which connection design has a better effect on the stability of the screw. However, it is difficult to draw conclusions from the articles selected as they cannot be compared directly due to the diversity of eligibility criteria’s, assessment methods, population in which study was done and outcomes. Seven papers were identified and included.

Katsuhiro Tsuruta et al (2018) conducted a study to assess the effect of implant–abutment connection on loosening of screw and microleakage. Three types of Nobel Biocare implants were utilized in the study. One compressive and tensile load was applied every second and loading was done for 2000 cycles. Removal Torque Value (RTV) of abutment screw was tested. No notable difference was seen between the groups.10

Hakimeh Siadat et al (2018) evaluated the effect of different connection designs on screw loosening and microleakage following cyclic loading effect of implants. 12 samples were divided into two groups: internal and external hexagon. Two implants were
used as control. Five minutes after tightening the abutment, the initial torque loss (ITL) was evaluated using a torque wrench. Metal crowns were placed on abutments before loading was carried out. Secondary torque loss (STL) was evaluated. ITL was more than the STL in both groups.\(^\text{11}\)

Eun-Sook Kim et al (2013) evaluated the effect of various abutment designs on initial loosening of screw. Three groups of abutments were fabricated with different fabrication methods. A dynamic load was applied and removal torque value before and after loading was evaluated. There was no notable difference in removal torque value amongst the groups. The abutment types did not have a notable influence on screw loosening.\(^\text{12}\)

Hyon-Mo Shin et al (2014) evaluated the effect of various abutment connection designs and the diameter on stability of screw joint. Regular diameter and wide-diameter implants with different types of connection designs were used. Initial removal torque values of screw was evaluated with a torque gauge. Postload removal torque value was evaluated after cyclic loading was done. The post-load removal torque value was highest in two-stage internal cone and least in external butt joint systems.\(^\text{13}\)

Jack Piermatti et al (2006) evaluated the torque loss with external hexagon and internal hexagon connection design. Ten samples of each system were utilized. Screws were tightened and loading was done. The Bio-Lok samples lost about 10% of torque, almost all torque of Astra Tech group was lost and it loosened, whereas 50% of the torque was lost of Nobel Biocare and Zimmer samples but it did not loosen. This study did not indicate advantage of internal connection over external hex connection related to loosening of the screw.\(^\text{14}\)

Yasuhiro KATSUTA et al (2015) evaluated the screw loosening of dental implant-abutment joint by cyclic torsional loading. 36 samples, 6 samples from each different abutment systems available commercially were utilized. Internal connection system (four groups) and external connection system (two groups) were used. The screw was tightened for every system and the loosening torque was evaluated by a digital torque meter. Cyclic torsional loading was performed and the loosening torque was evaluated. It was concluded that the abutment screw loosened due to cyclic torsional loading, and the amount of loosening differed with every system.\(^\text{15}\)

Abílio Ricciardi Coppedê et al (2013) conducted a study to evaluate the loosening torque in different connection designs. Abutments were tightened and loosening torque was evaluated. Abutments were retightened and mechanically loaded. The loosening torque was again measured. Significant differences between the groups were observed before mechanical cycling. No significant differences were seen among the groups after mechanical cycling. Within the same group, significant differences were observed before and after mechanical cycling loading.\(^\text{16}\)

**RESULTS**

Out of 7 studies, three studies stated that internal hex connection design had least screw loosening compared to external hex and morse taper (one study stated that external hex had the highest screw loosening whereas the other two studies stated that morse taper connection had higher incidence of screw loosening) while the other studies were inconclusive (Table 2).

![Table 2](image-url)
<table>
<thead>
<tr>
<th>Page</th>
<th>Group A (Block Abutment)</th>
<th>Group B (Gold cast abutment)</th>
<th>Group C (CAD/CAM custom abutment)</th>
<th>Removal Torque Value (RTV)</th>
<th>Screw loosening with stock abutment was the least and that with CAD/CAM abutment was the highest</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Dr. Prema N Kulkarni et al, International Journal of Medical and Biomedical Studies (IJMBS)</td>
<td>2013 korea</td>
<td>Group A (Block Abutment)</td>
<td>Group B (Gold cast abutment)</td>
<td>Group C (CAD/CAM custom abutment)</td>
</tr>
<tr>
<td>4a</td>
<td>Hyeon-Mu Shin et al.</td>
<td>2014 korea</td>
<td>Group A (External Hex Butt Joint)</td>
<td>Group B (8° Morse Taper)</td>
<td>Group C (11° Morse taper)</td>
</tr>
<tr>
<td>4b</td>
<td>Hyeon-Mu Shin et al.</td>
<td>2014 korea</td>
<td>Group A (External Hex Butt Joint)</td>
<td>Group B (8° Morse Taper)</td>
<td>Group C (11° Morse taper)</td>
</tr>
<tr>
<td>6</td>
<td>Yasuo KITADA and Fumihiko WATANABE</td>
<td>2015 Japan</td>
<td>Group A (Internal 8° Taper)</td>
<td>Group B (Internal 11° Taper)</td>
<td>Group C (Internal &quot;tube in tube&quot; with cam-dot)</td>
</tr>
<tr>
<td>7</td>
<td>Abhishek Rizziardi Coppolz et al.</td>
<td>2015 Brazil</td>
<td>Group A (Flat-head screw EH Connection)</td>
<td>Group B (Flat-head screw ET Connection)</td>
<td>Group C (Canal head screw ET Connection)</td>
</tr>
</tbody>
</table>

**Note:** The table above summarizes a variety of studies comparing different types of abutments and their associated torque values and loosening rates. The studies involve different implant systems and loading conditions, such as cyclic torsional loading and static loading, and measure the force required to remove the abutment or the rate of loosening over time. The results highlight the importance of selecting appropriate abutments and loading protocols to ensure long-term implant stability.
LIMITATIONS:

Some studies don’t give a definite conclusion because of the smaller sample sizes, differences in implant system used for the study, variety of groups compared, and relevant articles being available in languages other than English. Only one of the studies selected compared all the types of implant abutment connections i.e. Internal Hex, External Hex and Morse Taper connections at one time.

CONCLUSION:

Screw loosening is a common complication of implant treatment. The abutment screw stability is affected by implant-abutment connection design. Various connection designs such as internal hexagon, external hexagon and morse taper are available. Therefore, it is important to study the effect that the different connections may have on the screw stability. Various studies showed that screw loosening occurred to some extent irrespective of the connection design used. Out of 7 studies, three studies stated that internal hex connection design had least screw loosening compared to external hex and morse taper. Two other studies stated that there was no difference in the screw loosening associated with different implant abutment connection designs whereas the other studies were inconclusive. It is difficult to draw conclusions at this stage relating to the eligibility criteria, different implant-abutment connection designs. Clinical trials with bigger sample size where the confounding factors are controlled are necessary to evaluate the findings.

FUTURE IMPLICATIONS:

Studies with larger sample size and long term follow up; studies pertaining to all different kinds of connections in same sample may be carried out to evaluate which amongst the implant abutment connections i.e. Internal Hex, External Hex and Morse Taper have the least screw loosening associated with it.

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REFERENCES:


